Developing great teachers through professional development: a comparative international case study in England, Israel, South Korea, and Turkey

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Abstract

This comparative international case study explores teacher quality, that is, how teachers, who are regarded as great, train and develop. In particular, the thesis investigates ways in which participation in professional development programmes contributes to teachers' professional knowledge and the personal virtues involved in teaching chemistry at secondary school level in England, Israel, South Korea, and Turkey as case study nations.

The study employs a comparative case study approach. Empirical data collection was preceded by a document analysis and a comprehensive literature review which revealed three themes, namely community of practice, pedagogical content knowledge, and professional beliefs and virtues as impacting teachers in becoming great teachers. These themes were explored in practice utilising qualitative data collection methods, namely semi structured interviews with science teachers (mainly chemistry) who participated in professional development programmes and through observing lessons and professional development activities of teachers teaching science to 14-18-year-olds. Data was collected in South Korea, Israel, Turkey, and the United Kingdom (England) over a 1-year period. A volunteer sample of 40 science teachers (10 teachers for each country) were interviewed. Ten professional development activities were observed. The total length of observed PD activities was 1500 minutes. Nine science teachers were observed in four countries. The total length of observed lessons was 525 minutes. Four focus group interviews with the participation of 18 teachers were conducted. Thematic analysis was used to analyse the data.

The data shows that great teacher appears differently in the four nations. A great teacher is identified variously as an amalgamation of a *lifelong learner* (South Korea), a *moral exemplar* (Turkey), a *reflective practitioner* (England), and an *educator* (Israel). Great teachers as lifelong learners promote students' practical wisdom and wise decision-making ability, skills which are required to live a good life. Moral exemplars transmit their personal moral values to their students. Reflective practitioner teachers demonstrate intellectual and performance virtues in practice. As educators, great teachers motivate their students to be good human beings. The results of the study reveal that practical wisdom is an essential lens for making teachers educationally wise people. Great teacher is perceived to empower practical wisdom, which helps teachers establish mutual understanding and let them have more space to draw upon intellectual, social, moral and performance virtues through collaboration, mutual engagement and sharing in community of practice. The teachers in the study who participated in community-based professional development programmes enhanced the intellectual, moral, performance, and social virtues, pedagogical content knowledge associated with being a great teacher. The study finds that nations whose educational systems build strong connections between teachers through development and application of learning communities tend to generate a higher proportion of great teachers and that those teachers have positive and extensive influences on each other's intellectual and personal development. This research also found that one of the most important dispositions that enable teachers to become responsible for students' learning is passion in science teaching. The teachers' passion, motivation, and love for teaching helped them to expand their professional knowledge and techniques of instruction in distinctive manners. The character traits that a great teacher must possess should receive a lot of consideration. Emphasise also should be on developing character strengths in the professional development. Community of practice has potential to achieve this through mutual engagement, shared repertoire and joint enterprise.

The research emphasizes the vital role of teachers' passion for science teaching in enabling them to take responsibility for their students' learning. It advocates for the development of character strengths in teacher professional development, particularly through the cultivation of community of practice, characterized by mutual engagement, shared repertoire, and joint enterprise. This comparative study offers valuable insights into the dynamic interplay of teacher development, enhancing the quality of education across diverse contexts.

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Abbreviations

ACER: Australian Council for Educational Research

AcSS: Academy of Social Science

A Level: Advanced level examination taken in year 13 by 17–18-year-olds in England and Wales

AR: Action Research

ASE: Association for Science Education

AST: Advanced Skill Teacher

BERA: British Educational Research Association

CCT: Chartered College of Teaching

CK: Content Knowledge

CM: Consensus Model

CoP: Community of Practice

CSAT: Collage Scholastic Ability Test

DA: Dynamic Approach

DfE: Department for Education

GCSE: General Certificate of Secondary Education

ICT: Information and Communication Technology

IEA: International Association for the Evaluation of Educational Achievement

INSET: In-Service Training Day

ITT: Initial Teacher Training

KEDI: Korean Educational Development Institute

KNUE: Korean National University of Education

KS1: Key Stage 1: Years 1-2 (for children aged 5-7)

KS2: Key Stage 2: Years 3-6 (for children aged 7-11)

KS3: Key Stage 3: Years 7-9 (for children aged 11-14)

KS4: Key Stage 4: Years 10-11 (for children aged 14-16)

KS5: Key Stage 5: Years 12-13 (for children aged 16-18)

LS: Lesson Study

MAT: Multi-academy Trust

MoNE: Ministry of National Education

NEDP: National Education Development Project

NGSS: Next Generation Science Standards

NRC: National Research Council

NTET: National Teacher Evaluation Test

OECD: Organisation for Economic Cooperation and Development

OTOP: Oregon Teacher Observation Protocol

PB&V: Professional Beliefs and Virtues

PCK: Pedagogical Content Knowledge

PD: Professional Development

PGCE: Postgraduate Certificate of Education

PISA: Programme for International Student Assessment

PK: Pedagogical Knowledge

PLC: Professional Learning Community

QAA: Question Asking Ability

QT: Quality Teaching

QTR: Quality Teaching Round

QTS: Qualified Teacher Status

RAMA: The National Authority for Measurement and Evaluation in Education

RSC: Royal Society of Chemistry

SATURN: Science and Technology for Understanding, Research and Networking

SCALE: System-Wide Change for All Learners and Educators

SCITT: School-Centred Initial Teacher Training

SDG: Sustainable Development Goal

SES: Socio Economic Status

SFT: Schools for Thought

SKE: Subject Knowledge Enhancement

SMK: Subject Matter Knowledge

STeLLA: Science Teachers Learning from Lesson Analysis

TALIS: Teaching and Learning International Survey

TIMSS: Trends in International Mathematics and Science Study

TLPDFT: Teacher-led Professional Development for Teachers

TPD: Transformative Professional Development

TRA: Teaching Regulations Agency

YKS: Yuksek Kurumlar Sinavi

Glossary of Terms

Advanced Skill Teacher (AST): An AST was described as a great teacher who achieved the highest standards on teaching. It was a model maintained in England and Wales from 1998 to 2013.

Data set: Different groups from which data was collected such as professional development data set.

General Certificate of Secondary Education (GCSE): An academic qualification in a particular subject, taken in England, Wales, and Northern Ireland.

Independent School: A fee-paying school; some are endowed and governed by a board of governors and some are in private ownership.

Key Stage: A stage of the state education system in England, Wales, Northern Ireland and the British Overseas Territory of Gibraltar setting the educational knowledge expected of students at various ages.

Master teacher: A model in South Korea where teachers are considered as having extraordinary practice in teaching.

Ministry of National Education (MoNE): A government ministry of the Republic of Turkey, responsible for the supervision of the public and private educational systems, agreements and authorisations under a national curriculum.

Multi-academy Trust (MAT): Groups of academies that have come together to form a charitable company, with a single group of ‘members’ (who have an overview of the governance arrangements) and a single board of trustees.

Newly Qualified Teacher: Someone who has completed their initial teacher training and gained qualified teacher status (QTS) in England and Wales.

Postgraduate Certificate in Education (PGCE): A 1- or 2-year higher education course in England, Wales and Northern Ireland which provides training to allow graduates to become teachers within maintained schools.

Royal Society of Chemistry (RSC): A learned society in the United Kingdom with the goal of advancing the chemical sciences.

State-funded School: Commonly known as state schools, these provide education to pupils between the ages of 3 and 18 without charge.

Teacher Leader: A model in Israel where teachers participate in professional development activities and are recognised as great teachers.

The Association for Science Education (ASE): A professional association in the United Kingdom for teachers of science and science technicians.

Declaration

The material contained within this thesis is the sole work of the author. It has not been previously submitted for any other award at Durham University, or any other institution.

Statement of Copyright

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Dedication

Dedicated to the memory of Dr Per Morten Kind (1960–2017) of Durham University School of Education

Chapter 1: Introduction

"Learning from an unknown future cannot be accomplished by the acquisition of either knowledge or skills. There is always an epistemological gap between what is known and the exigencies of the moment as it invites responses, and this is particularly so in a changing world. A more positive term, to encapsulate right relationships between persons and the changing world in which they are placed, might be 'wisdom'".

-Barnett, 2012, p. 75-76

In this introductory chapter, I begin by outlining my personal interest, the rationale for the research and the design of my PhD research into teacher professional development (PD) in four nations and its impact on teachers' practices (in Section 1.1). Section 1.2 describes the knowledge gap that the research seeks to fill. In Section 1.3, research questions are presented. Section 1.4 explains how the thesis is structured.

1.1 Personal interest and the rationale for the research

The United Nations (UN) has set sustainable development goals, with one of them being to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' (Jensen, 2019, p. 30). The UN emphasizes that quality education is a key component for achieving sustainable development. The European Commission (2021) similarly underscores the importance of providing quality education as a means to address societal issues.

To understand what 'quality' means in the context of teacher education, it's helpful to look at specific definitions. Professional development, often referred to as PD, plays a crucial role in this endeavor. Professional development involves a continuous process through which educators acquire and refine their knowledge, skills, and competencies necessary for excellence in their roles (Van Veen et al., 2012; Van Driel et al., 2012). It encompasses a wide range of activities and opportunities designed to enhance educators' expertise, pedagogy, and classroom practices, with the ultimate goal of improving teaching and learning outcomes (Rogers et al., 2007).

Moreover, to achieve this goal, it is essential to define what constitutes a 'great teacher.' In her study of high-achieving countries such as Australia, Canada, China (Shanghai), Finland, and Singapore, Darling-Hammond (2021) provides a comprehensive definition of teacher quality. According to her research, 'great teachers' are those who possess a profound professional knowledge, which includes a deep understanding of content, pedagogy, and the diverse needs of learners. Notably, this understanding is essential for promoting high-quality education and enhancing learning outcomes.

In addition to teacher quality, the concept of wise educational judgment, often referred to as practical wisdom, plays a pivotal role in achieving quality education. Practical wisdom encompasses the ability of educators to make informed, context-specific decisions by drawing on a combination of professional knowledge, experience, ethical considerations, and a deep understanding of students' needs (Urhahne and Wijnia, 2021; Murris and Verbeek, 2014). Educators with practical wisdom can adapt and innovate in response to the unique challenges and opportunities they encounter in their classrooms, ultimately contributing to the cultivation of 'great teachers' and the delivery of quality education (Biesta, 2016).

A review study conducted by the Australian Council for Educational Research (ACER) in 2016 proposed an equation for defining quality education. According to this equation, quality is a product of various competencies, productive behaviors, and the catalytic impact of personal attributes (Bahr & Mellor, 2016). The elements that contribute to quality education, as identified by this review, include personal characteristics such as setting high expectations for all learners, kindness, fairness, humor, and an overall positive approach to teaching. These characteristics encompass classroom and behavior management, pedagogy, and knowledge.

The review study also highlights seven competencies and behaviors as crucial for teachers' practice. These are deep knowledge of learning, discipline knowledge, pedagogical content knowledge (PCK), behavior management, assessment and data analysis knowledge, personal and professional literacy and numeracy, and professional relationships. These competencies and behaviors collectively contribute to the overall quality of teaching and education

As a student in high school, I looked forward to attending chemistry classes thanks to my chemistry teacher. What made her distinctive was her caring for all her students and going the extra mile for us. She prepared the best classes using various instructional strategies to get us engaged on the topics that she taught. She has always been a role model for me. I felt that she had personal attributes such as kindness, care, a positive attitude toward teaching and learning, and was quick to understand students' needs, which let her combine content, pedagogy, and learners to lead students to success. She was a great example of how chemistry can be taught and who a great chemistry teacher should be.

While doing my Master's degree at Brunel University, London, I developed an interest in the notion of 'providing quality in teacher education'. A module entitled *Discipline of Education* delivered by Professor Gert Biesta inspired my interest in conducting this research. In his seminal work, *The Beautiful Risk of Education*, he provided an alternative viewpoint to understand the needs for quality in teacher education. Biesta (2016) stated, "the main focus is on the development of a certain virtuosity in making educational judgements—not, again, as a set of skills or competencies but rather as a process that will help teachers to become educationally wise" (p. 137). Biesta notes that in addition to acquiring knowledge, skills, and dispositions, which he refers to the domain of qualification, a teacher should have wise educational judgement. Biesta refers to wise educational judgement/practical wisdom as a character virtue, which influences teachers' decision making about what works the best in the classroom to teach the subject (Biesta, 2016). As a teacher, I found it demanding and challenging to figure out what qualities I needed to improve students' academic and non-academic achievement. Therefore, I found it essential to delve deeper into the precise definition of wise educational judgement or practical wisdom and explore why and how it plays a role in teachers' practice. To embark on this exploration, it is crucial to establish a clear definition of wise educational judgement and its components. Furthermore, the study will examine the specific ways in which these components manifest in the classroom and impact teaching methods. By doing so, we aim to uncover the underlying principles that guide educators in making informed, contextually appropriate decisions in their teaching practice. This investigation will shed light on the critical interplay between wise educational judgement and the previously identified factors in shaping great teacher.

Additionally, during my three years as a chemistry teacher, I encountered issues related to the practices of chemistry teaching. In line with Turkey's context-based chemistry curriculum

(Ministry of National Education (MoNE) in Turkey, 2013), I was supposed to teach chemistry using topic- and subject-specific strategies models, such as macro-micro modelling for teaching chemical reactions. Some topics in chemistry are confusing and abstract. For example, when I taught electrochemistry, I experienced conceptual difficulties while describing chemical and electrochemical equilibrium to students in examination courses (aged 17–18). I reasoned that it was not because I lacked subject matter understanding, but because there were certain pedagogical elements lacking in my teaching that made it challenging to teach abstract issues, resulting in non-meaningful learning. I participated in in-service training programmes to address this issue, but they did not help me enhance my teaching. There were two reasons behind this. First, the workshop specialists provided little audience engagement during PD workshops. We were passive listeners and not able to talk to each other. As in this case, PD workshops did not provide us with active learning opportunities. Second, the workshops were only offered for a limited time. As a result, there was little time to reflect on my own practice after I implemented a new approach in my lessons.

Since I was the only chemistry teacher at my school, I was unable to collaborate with other chemistry teachers. I was responsible for my own learning. I would argue that my struggles to become a better teacher were hindered for two reasons: a lack of opportunities for participating in professional development and collaborating with my colleagues. In the case of my chemistry teacher, she served as an example for other teachers. While I was the only chemistry teacher at my school, I lacked a mentor or coach who could serve as a role model for great teacher. If I had role models around me, I stood a better chance of improving my teaching abilities. It's important to note that not all mentors are guaranteed to be exceptional teachers, but having guidance and experience to draw from could have positively influenced my development.

In the context of this study, it's crucial to understand how the grading categories of education systems, as described by McKinsey & Company's (2010) report on improving school systems, relate to the emphasis on practical wisdom and achieving 'great' teaching outcomes. The report categorizes systems into 'poor to fair', 'fair to good', 'good to great', and 'great to excellent', each representing different stages of a nation's education journey (Mourshed, Chijioke & Barber, 2010).

The classification of educational systems into four levels, ranging from 'poor to fair' to 'great to excellent,' illustrates the diverse priorities of nations in their pursuit of educational excellence (Mourshed, Chijioke & Barber, 2010). Relating this framework to the study, it's vital to assess how practical wisdom and the quest for 'great' teaching align with these gradings and their corresponding educational objectives. Integrating insights from Biesta (2012) can provide a more comprehensive understanding of the role of practical wisdom and 'great' teaching within these systems. Biesta's work emphasizes moving beyond the acquisition of basic skills and delves into the moral, political, and cultural dimensions of education. He highlights that education should not be solely instrumental but should also foster critical thinking, ethical decision-making, and active citizenship. In this context, the educational grading levels, such as 'poor to fair' and 'good to great,' offer insights into how different nations prioritize the pursuit of educational excellence, aligning with Biesta's call for a more comprehensive view of education.

The exploration of professional development (PD) interventions and initiatives implemented by educational systems with the goal of advancing towards excellence and nurturing exceptional teachers is a significant undertaking. In the context of England, it is noteworthy to highlight the proactive approach adopted by educational policy makers in addressing the unique requirements within the realm of education (Wilson, 2013). In order to improve the calibre of educators, England implemented a programme known as Subject Knowledge Enhancement (SKE) courses. These courses were specifically developed to equip aspiring teachers with a deep understanding and proficiency in the subjects they plan to instruct. By offering trainee teachers the opportunity to enhance their subject knowledge, England aimed to elevate the overall quality of teaching in the education system. These courses aim to bridge any perceived gaps in subject knowledge (Woolhouse & Cochrane, 2014).

In addition, it is important to highlight that the Chartered College of Teaching (CCT) assumes a significant position in the realm of professional development. Its primary objective is to enhance the calibre of professional development opportunities available to educators, as highlighted by the Department for Education in 2018. In recent years, the United Kingdom government has taken significant steps to improve the education system, including the establishment of 'Multi Academy Trusts' (MATs). These trusts have been introduced not only to support initial teacher training but also to provide a comprehensive structural framework for school organisation, with the aim of fostering improved educational standards. The implementation of MATs represents a strategic approach by the government to address the challenges faced by schools and to promote collaboration and accountability within the education sector. By bringing together multiple schools under a single trust, MATs offer a platform for sharing resources, expertise, and best practices. This collaborative model is believed to facilitate the dissemination of innovative teaching methods and pedagogical approaches, ultimately leading to enhanced educational outcomes. Furthermore, MATs serve as a mechanism for promoting effective governance and leadership within schools (Bernardinelli et al., 2018).

By centralising decision-making processes and providing a clear chain of command, these trusts aim to streamline administrative procedures and ensure consistent standards across all affiliated institutions. This centralised approach is expected to result in improved coordination and coherence in educational policies and practices. The establishment of MATs also aligns with the government's broader agenda of decentralisation and devolution of power in the education sector. By granting schools greater autonomy and flexibility in decision-making, MATs empower local communities and educators to shape the direction and priorities of their institutions (Bernardinelli et al., 2018). This localised approach is seen as a means to foster a sense of ownership and engagement among stakeholders, ultimately leading to a more responsive and tailored MATs play a central role in providing the environment for the best professional development opportunities for teachers (Department for Education, 2016).

The significance of the McKinsey (2010) study lies in its categorization of educational systems. However, it is important to acknowledge that the decisions made by educational policy makers and the impact of international assessments such as TIMSS and PISA play a crucial role in determining a nation's educational priorities (McKinsey, 2010). The assessments discussed in this statement hold considerable influence over the allocation of resources and the development of educational strategies. They frequently shape the trajectory of professional development (PD) initiatives. Bernardinelli et al. (2018) highlights the UK government's proposal to transform all schools into academies as a substantial reform endeavour with the objective of enhancing the comprehensive education system.

Avidov-Ungar and Reingold (2018) conducted an extensive study in Israel that focused on the implementation of the 'leader teacher' initiative by the Ministry of Education. The primary objective of this initiative was to foster continuous professional development (PD) opportunities for teachers within school settings. The present initiative also aimed to augment the calibre of pedagogical approaches and educational practices, capitalising on the extensive reservoir of knowledge and expertise possessed by educators. This literature review examines a study that investigated the experiences of a significant number of teachers, involving a substantial sample size. In the course of this investigation, an assortment of techniques were employed to gather pertinent data, encompassing surveys, classroom observations, and teacher interviews.

In their study, Russo-Netzer and Shoshani (2018) shed light on the significant contributions of teacher leaders in promoting professional development (PD) and instructional enhancements among their peers. The authors emphasise the pivotal role that teacher leadership plays in this initiative, highlighting its importance within the educational landscape. By examining the findings of this research, educators and policymakers can gain valuable insights into the strategies and approaches that teacher leaders can employ to effectively foster PD and instructional improvements among their colleagues. This study thus contributes to the existing literature on teacher leadership and offers practical implications for enhancing educational practices. The findings of this study suggest that when teachers take on the role of leader teachers, they have a notable impact on creating a positive school culture and shaping the professional identities of their colleagues. The provided information is crucial for comprehending the influence of leadership within the teaching community on the overall quality of teaching and the growth of exceptional educators.

In a study conducted by Mamlok-Naaman, Blonder, and Hofstein (2010), the researchers sought to investigate the impact of active learning opportunities within professional learning communities (PLCs) on the growth of teachers' Pedagogical Content Knowledge (PCK) and the improvement of their chemistry teaching practices. The researchers employed a mixed-methods approach, utilising various data collection methods such as classroom observations, collaborative group discussions, and pre- and post-assessments. These methods allowed for a comprehensive exploration of the teachers' practices and their impact on student learning outcomes.

In these studies, the researchers discovered a fresh and innovative approach to professional development (PD) in the field of education. This approach was centred around collaborative models, placing a strong emphasis on interaction and cooperation among teachers. The implementation of this approach resulted in the creation of active learning opportunities, which in turn led to more effective and enduring outcomes. This study provides valuable insights into the ways in which teachers can effectively cultivate their pedagogical content knowledge (PCK) and elevate their instructional approaches. By doing so, it contributes to the overarching objective of attaining exemplary teaching status and enhancing the overall standard of education.

The 'master teacher' model has been implemented in South Korea as a prominent strategy to provide guidance and support to novice or less proficient educators (Darling-Hammond & Rothman, 2011; Kim, 2015). The present model is designed with a well-organized structure that aims to offer essential assistance and direction, thereby fostering the growth and development of novice or less experienced educators in their teaching capacities.

The concept of the 'master teacher' model has been developed with the aim of providing support and assistance to teachers in various ways. The primary purpose of this tool is to assist educators in the formulation and implementation of pedagogical approaches that are proven to be effective. The achievement of the desired outcome is facilitated by employing a collaborative approach that fosters an environment where participants are encouraged to delve into their own perspectives and concepts. In addition, the proposed model effectively promotes the expansion of teachers' boundaries, thereby cultivating an environment that prioritises ongoing growth and inventive thinking. The 'master teacher' model is a pedagogical approach that emphasises the importance of dialogue, mentorship, and reflection in equipping teachers with the necessary skills and confidence to foster engaging and effective learning experiences for their students. This model recognises the significance of active engagement between teachers and their mentors, as well as the value of self-reflection, in enhancing teaching practices. By facilitating meaningful conversations and providing guidance, mentors play a crucial role in supporting teachers' professional growth. Moreover, through reflective practices, teachers are able to critically analyse their teaching methods, identify areas for improvement, and make necessary adjustments to optimise student learning outcomes. Overall, the 'master teacher' model offers a comprehensive framework that empowers educators to cultivate an enriching educational environment that promotes student engagement and achievement.

Meanwhile, Kim (2015) investigated master teachers' role in PD. The study showed that master teachers are responsible for helping to develop curriculum, design new instructions and develop novice teachers' teaching practice by observing their class. The master teacher model takes a major role in developing authentic activities in PD, as well as in assisting teachers to increase their professionalism and raise accountability of teachers (Park & So, 2014).

Similarly, in Turkey's educational landscape, several distinct characteristics are associated with professional development (PD) workshops. These workshops are often characterized by a lack of collaboration, where educators may find limited opportunities to work together and share insights. Sustainability and maintenance of the knowledge gained in such workshops are frequently challenging, with the newly acquired skills or practices struggling to take root in the long term. In Turkey, the lack of collaboration, poor levels of sustainability and maintenance, frequent short-term nature, and disregard for teachers' needs are characteristics of PD workshops (Aydin, Demirdogen, Tarkin, Kutucu, Ekiz, Akin, Tuysuz, & Uzuntiryaki, 2013). These characteristics nature of PD in Turkey result in having little or no impact on teachers' practice (Aydin et al., 2013). Bayar and Kösterelioğlu (2014) highlighted one of the most reasons that makes PD in Turkey ineffective is the lack of authentic activities that are real and relevant to the classroom environment. Activities in the PD should be applicable and transferable to classroom context. An experimental study carried out by Balta and Eryilmaz (2019) in Turkey with the participation of six high-school physics teachers (from six high schools) and 306 tenth grade students (15-17-year-olds) investigates how the teacher-led PD for teachers impact on teachers' content knowledge (CK). Findings from the study showed that teachers' active engagement resulted in the building of an effective professional community in which teachers discussed and shared ideas and instructions with each other.

The research spans several distinct educational contexts in South Korea, Israel, England, and Turkey. While each nation employs unique strategies, the common thread is the pursuit of high-quality teaching and the cultivation of 'great teachers.' South Korea relies on the 'master teacher' model, which emphasizes dialogue, mentorship, and reflection, while Israel places its trust in teacher leaders and England introduces Subject Knowledge Enhancement courses and Multi Academy Trusts. In Turkey, the challenge lies in underdeveloped PD workshops with limited collaboration and sustainability. This research seeks to assess the effectiveness of these initiatives and explore the influence of practical wisdom, as inspired by Biesta, in enhancing teaching quality across these diverse educational landscapes. Notably, it's worth mentioning Dillon (2016) study on professional development and the Wellcome Trust's publication, 'Believers, Seekers, and Sceptics,' (Matterson, 2005) as valuable sources of insight in this context. The need for this study arises from the shared goal of advancing teaching quality and learning from diverse strategies implemented in these nations to bridge the gap between PD and impactful teaching practice.

1.2 The gap in research

Studies in general focus on perceptions of high-achieving countries on PD (Darling-Hammond 2021; Darling-Hammond et al., 2017) or a comparative study of two countries' PD based on the usage of secondary data such as PISA, TIMSS, and Teaching and Learning International Survey (TALIS) results (Ainley and Carstens, 2018; Thomson and Hillman, 2019; Jerrim and Sims, 2019). Knowing how high-achieving countries train their teachers is valuable, but methods are difficult to adopt directly because a PD model that works well for one country, may not apply elsewhere.

Second, this research aims to contribute to what great teacher is based on four countries' perceptions. Biesta (2007, 2012), for example, claims three domains, which are qualification, socialisation, and subjectification, are required to generate great teacher. 'Qualification' refers to teacher professional knowledge (SK, CK and PCK), competencies, dispositions and skills that teachers need to teach their subject. 'Socialisation' refers to imparting the beliefs and cultures that allow teachers to live and function within current social systems and perform what teachers are expected to do. ‘Subjectification’ refers to make wise educational judgement which is about how to use domain of qualification to make decision what works in the classroom. The literature on great teacher’s focuses on the qualification domain, less emphasis is made on the domain of socialisation which includes teachers’ professional, social and personal development and the domain of subjectification, which refers to wise educational judgement/practical wisdom.

There is a research gap between theory and practice in the existing literature on defining what a great teacher is (Cheng et al., 2010; Allen, 2009; Sancar et al., 2021; Reinholz and Andrews, 2020). Furthermore, how such teachers are developed has received little attention. My study attempts to address this by examining how PD influences teachers’ qualities to become a great teacher in four nations. This study contributes to a comparative international case study of teacher PD and its impact on teaching practice in four countries.

Biesta (2012) contends that wise educational judgment/practical wisdom is required for teachers to be aware of the pedagogical beliefs and professional knowledge behind what works best in the classroom to effectively deliver content and pedagogy to learners. investigating how PD can support wise educational judgment/practical wisdom of teachers is worthwhile.

1.3 Research aims and questions

As a comparative international case study, the three objectives of this study were as follows:

- To investigate how PD contributes to teachers’ practice in four countries, identifying their similarities and differences in practices
- To investigate teachers’ perceptions of being a ‘great teacher’ in four nations
- To investigate how and why (if at all) teachers gain wise education judgment/practical wisdom

The research questions (RQs) are:

1. In what ways are the educational systems of four nations (England, Israel, South Korea, and Turkey) providing teacher PD that contributes to their teachers' practices? In each of these nations:
2. In what ways is the notion a 'great teacher' perceived in science teacher education in these four nations?
3. How and why (if at all) do teachers gain wise educational judgement/practical wisdom?

1.4 Thesis Structure

This thesis comprises seven chapters. Following this chapter, Chapter 2 focuses on the literature, which reviews understandings of PD and its impact on teachers' practice. Additionally, a definition of great teacher is presented. A theoretical framework is developed by extending the teacher quality framework to identify teachers' qualities through CoP. Chapter 3 analyses the educational systems of the four nations such as England, Israel, South Korea, and Turkey and presents document analysis. Chapter 4 outlines the methodology and research design and sets out the research methods used to analyse the qualitative data obtained in the four nations. It deals with ethical considerations, reliability and validity, and explains the data analysis process. In the fifth chapter, a comprehensive presentation of data from various sources is provided, accompanied by a detailed account of the systematic process employed for organising these data sets. Chapter 6 presents the conclusion of the study regarding research questions. Chapter 7 addresses implications arising from the study for teacher professional development, discussions limitations and makes recommendations for future research.

Chapter 2: Literature Review

"Making educational judgements - not, again, as a set of skills or competences but rather as a process that will help teachers to become educationally wise".

-Biesta, 2016, p. 137

2.1 Introduction

Professional development (PD) for teachers is essential to support teachers in improving their content knowledge (CK) and pedagogical knowledge (PK), and change their pedagogical beliefs behind decision making. Participation in a Community of Practice (CoP) typically involves educators coming together to share expertise, collaborate, and engage in a sustained, collaborative learning process and has been regarded as an effective form of PD, in comparison to short-term, one-sided and non-collaborative PD (DuFour, 2014; Zepeda, 2019). My research, therefore, focuses primarily on how PD contributes to teachers' practice, indicating ways of developing great teachers through effective PD based on teachers' perspectives from four countries.

Following the introduction, Section 2.2 gives brief information about what effective PD looks like in teacher education. In Section 2.3, literature is examined with a focus on how CoP support teachers in developing their practice, specifically the concepts of participation, reflection and collaboration. Section 2.4 focuses on teacher qualities supported by PD, with a particular emphasis on teachers' professional knowledge. While section 2.5 focuses on professional beliefs, and character virtues. This section critiques perceptions of 'great teachers' and defines the term 'great teacher'. Section 2.6 discusses the concept of wise educational judgement/practical wisdom and how this is emphasised in developing teachers' practice. Section 2.7 provides a theoretical framework for understanding how teacher communities foster teachers' practice and personal development with a particular focus on Wenger's (1998) communities of practice. This section explains why community of practice (CoP) is the best and suitable framework for this study. Finally, Section 2.8 provides the summary of the literature review.

2.2 Professional development as a means of developing teachers' practice

In academic discussion, researchers such as Blonder & Vescio (2022) and Zepeda (2019) inquire into how to support teachers to improve their practice. These researches highlighted that PD encourages teachers to improve their practices throughout their career. Investigating high-quality PD, and how this supports teachers' practice promotes better understanding of how to be great teacher. This section introduces research literature about high-quality PD and how this helps teachers to develop their practice.

Desimone's study (2009) on the relationship between PD and its impact on teachers' practice and student achievement involved a comprehensive analysis of existing literature. Desimone examined a wide range of research studies and documents to draw conclusions regarding the effects of PD. While her study did not involve original data collection, it encompassed various empirical studies and educational research from multiple countries, including the United States, Canada, Australia, and several European nations. Her research provides valuable insights into the link between PD and its impact on teachers' practice, ultimately influencing students' achievement (Figure 2.1). Desimone's perspective suggests that PD can lead to improvements in teachers' knowledge, including CK, PK, and PCK. This enhanced knowledge, in turn, can result in improved instructional practices, with potential positive effects on student outcomes and achievement.

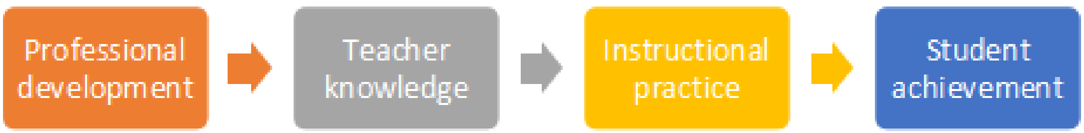


Figure 2. 1: Link between teacher PD and students' achievement. (Desimone, 2009)

Desimone's study (2009) pointed out that effective professional development helps teachers deepen their understanding of subject-specific content knowledge. This includes a comprehensive grasp of the key concepts, principles, and theories within their field. By expanding their CK, teachers can better contextualize the material for students, ensuring accurate and comprehensive delivery of content. For instance, a science teacher with a strong understanding of scientific principles and theories can convey complex scientific concepts more effectively, fostering students' understanding and interest in the subject.

She further added that professional development supports the development of pedagogical knowledge, which refers to the understanding of various teaching strategies, methods, and classroom management techniques. By acquiring a diverse range of pedagogical skills, teachers can create engaging and effective learning environments, catered to the diverse needs of students. Effective PD can introduce teachers to innovative instructional methods, such as active learning techniques, differentiation strategies, and the incorporation of technology in the classroom, enabling them to adapt their teaching approaches to best support student learning.

In addition, her study revealed that PD also focuses on enhancing teachers' PCK, which involves the integration of both content knowledge and pedagogical knowledge. This unique blend allows teachers to effectively convey complex concepts in a manner that is comprehensible and engaging for students. By strengthening their PCK, teachers can create meaningful learning experiences that connect theoretical concepts to real-world applications. For instance, a history teacher with strong PCK can effectively design activities and projects that help students relate historical events to contemporary issues, fostering a deeper understanding of the subject matter.

Through professional development, teachers can continuously refine and expand their CK, PK, and PCK, thereby enhancing their instructional methodologies. As they deepen their understanding of subject matter, teaching strategies, and the integration of both, they can create more engaging and effective learning experiences for students. This comprehensive development of knowledge and skills enables teachers to adapt their instructional approaches to the diverse needs and learning styles of their students, ultimately fostering a more impactful and conducive learning environment.

On the other hand, Supovitz and Turner (2000) conducted a study in the United States, focusing on the effects of professional development on science teaching practices and classroom culture. Their research employed a mixed-methods approach, combining qualitative observations and surveys to assess changes in teaching methods and the classroom environment following PD interventions. The survey included a varied sample of teachers and administrators from 24 US cities, offering a national perspective on scientific instruction and support. These communities included San Francisco, Chicago, Waltham, Massachusetts, Mesa, Arizona, Elizabeth City, North Carolina, and Midland, Michigan. The research sampled 173 instructors in the smallest experiment and 2,027 teachers in the biggest. A random sampling of 300 science instructors from each LSC project ensured representativeness. In spring 1997, 4,903 instructors from 787 schools completed LSC questionnaires. The dataset included questionnaires from 3,464 science instructors and 666 administrators in 24 areas after deleting incorrect replies owing to missing data or linked information. They found that targeted and sustained PD programs positively influenced teachers' instructional practices and contributed to a more conducive classroom culture, fostering student engagement and learning.

Similarly, Hawley and Valli's research (1999) explored effective professional development strategies in the context of the United States. It examined the experiences of teachers engaging in collaborative learning communities. This research collected data using a quantitative survey approach to construct a technology integration model and identify teacher training requirements. This research used stratified random sampling to choose 400 primary school teachers from 10 Cameroon Regions to determine their professional development model preferences. Their findings emphasized the significance of collaborative and reflective approaches, enabling teachers to share experiences, exchange ideas, and refine their instructional practices. They highlighted the importance of sustained support and reflective practices in enhancing the efficacy of PD initiatives.

Meanwhile, in a European context, Hauge's study (2019) focused on collective professional development within schools. The research employed a systematic literature review methodology, synthesizing findings from various European countries. The study presents research from 23 articles from 2015 to 2017. This review covers nine European, seven American, four Asian, and three Australian papers. It emphasized the collaborative nature of PD within schools, highlighting the benefits of shared learning experiences among educators and the role of collective knowledge building in improving teaching practices and student outcomes.

Furthermore, Blonder and Vescio (2022) contributed to the literature by examining Professional Learning Communities' differentiation across science teachers' careers. Their research, situated in the context of the United States, used a case study approach, incorporating interviews and observations to understand how varying PD approaches within PLCs impacted teachers' professional growth. They highlighted the importance of tailoring learning experiences to meet the diverse needs of teachers at different stages of their careers, fostering continuous development and growth.

Smylie, Bilcer, Greenberg and Harris (1998) conducted their research in an urban setting in the United States, focusing on the professional development experiences of urban teachers. Their qualitative study involved in-depth interviews and classroom observations, shedding light on the specific challenges faced by educators in urban contexts. They emphasized the need for PD programs to address contextual factors such as diverse student populations, limited resources, and community dynamics to effectively support teachers in these settings.

The studies by Cohen and Hill (2000) and Corcoran and Goertz (1995) were centered in the United States and focused on the influence of instructional policies and school capacity on professional development efficacy. This study closely aligns with Tashakkori and Teddlie's Type VII, a parallel mixed model study, whereby both quantitative and qualitative aspects are central and simultaneously considered during problem formation, data collection, and data analysis. The Tier 1 study compares 943 experienced secondary science teachers (ETs) with 340 excellent ETs with 10+ years of teaching experience. Tier two include qualitative, included a case study of four PAs, including classroom observations and semi-structured interviews.

Cohen and Hill (2000) research employed a mixed-methods approach, examining the impact of mathematics reform policies on classroom performance. Corcoran and Goertz (1995) study focused on instructional capacity and high-performing schools, highlighting the role of organizational support and leadership in shaping effective PD initiatives. Both studies underscored the importance of aligning PD programs with broader educational goals and systemic factors to achieve meaningful and sustainable impact.

Consequently, effective professional development should be tailored to meet the specific needs of teachers, considering the diverse contexts in which they operate. It should foster collaborative learning environments, allowing for knowledge exchange and shared best practices. Moreover, it should integrate subject-specific content knowledge with effective pedagogical strategies to enhance teachers' instructional capabilities. Additionally, effective PD should be sustained over time, providing continuous support and opportunities for reflection and application. It should encourage active participation, hands-on learning experiences, and provide educators with the autonomy to apply new strategies in their classrooms. In conclusion, high-quality PD should provide teachers with collaborative environment with the focus on reflective practice. Collaboration could be fostered by experienced, master, or leader teachers. Therefore, collaboration between novice and experienced teachers in PD is vital for developing novice and experienced teachers’ practice. The next section explains the integration of CoP into PD.

2.3 Community of Practice (CoP)

Community of Practice (CoP), which provides teachers with a collaborative space to share knowledge, experiences, and best practices, have become essential components in educational environments. Li, Grimshaw, Nielsen, Judd, Coyte and Graham (2009) emphasize the development of Wenger's concept of CoP, which offers educators a structured setting for collaboration and the promotion of ongoing learning. Educators are able to improve their pedagogical skills and broaden their knowledge of teaching approaches by participating in these communities, which act as platforms for professional development.

From a Habermasian perspective, O’Donnell, Porter, McGuire, Garavan, Heffernan and Cleary (2003) present the idea of CoP and emphasize its significance in the creation of intellectual capital. The development of efficient teaching practices is eventually aided by CoP in the field of education, which facilitate the communal creation of knowledge and expertise. Mercieca (2017) also conducts a thorough investigation of CoP, emphasizing their significance in promoting knowledge exchange, reflective teaching, and the receiving of helpful criticism among educators. These communities have a big impact on teaching approaches since they provide a collaborative approach to professional advancement within the educational landscape.

In their discussion of faculty development in the context of online learning, Reilly, Vandenhouten, Gallagher-Lepak and Ralston-Berg (2012) quatitative study emphasize the potential of Communities of Practice (CoPs) in assisting educators in adjusting to new teaching strategies and technology. In order to improve teaching practices, these communities allow the exchange of e-learning-related experiences, strategies, and resources. According to Hermita, Wijaya, Fauza, Mulyani, Alim and Putra (2021), CoP is essential for raising the performance of primary school teachers. CoP fosters PD and better instructional results by providing a safe space for educators to share struggles and triumphs, exchange teaching ideas, and generally improve their teaching skills.

Egg, Kapelari and Dillon, (2017) explore how social network architectures are visualized in professional learning communities. Teachers are better able to identify important collaborators, mentors, and information sources because to the visual portrayal of links within CoP, which also facilitates the exchange of best practices and the development of teaching skills. In his reflections on self-studies and the training of aspiring science teacher educators, Dillon (2016) highlights the value of CoP in introspection and the dissemination of findings from self-studies. For educators to improve their teaching practices and enhance their professional development, these communities provide a valuable resource.

Tummons (2022) examines the role of CoP in adult and postsecondary education, emphasizing how these partnerships foster expertise, apprenticeship, and a sense of community. CoP enables teachers in educational contexts to grow their areas of expertise and forge a sense of identity as professionals. Tummons (2022) also examines craft, knowledge, expertise, and practice, highlighting the significance of each for the role of a cycle technician. These observations also apply to teaching, where CoP is essential in the advancement of educators' professional skills in the areas of pedagogical topic knowledge and classroom management.

In summary, the empirical research indicates that CoP is essential to teachers' professional development. They provide a cooperative and introspective atmosphere that encourages the exchange of knowledge, the improvement of teaching practices, and the formation of a sense of professional identity among educators. The development of teaching skills in educational contexts is facilitated by these communities, which act as catalysts for ongoing learning.

2.3.1 Features of CoP

Wenger (1998) Community of Practice (CoP) include three key elements. First, "Mutual Engagement" means people actively participate in the community, engage, and collaborate with a goal. Second, "Joint Enterprise" promotes community goals and activities by uniting people behind a single enterprise. Finally, "Shared Repertoire" includes members' cumulative resources, experiences, and expertise. CoP is active and collaborative, where members connect, work together, and draw from a shared pool of experiences and resources to encourage learning, expertise, and belonging (Wenger, 1998).

Participation is portrayed as central to situated learning as identity, knowledge and practices develop through participation. Participation for becoming active participants in social communities and developing identities in connection to communities rather than local occurrences of involvement in particular activities with certain persons. Participation as defined by Wenger (1998) is interconnected with collaborative activities, relationships and connections with people in the community. Experienced workers learn through their interactions with novices, and assisting other workers in learning is part of the process of legitimate peripheral participation for other participants (Fuller, Hodkinson, Hodkinson, & Unwin, 2005). Legitimate peripheral participation refers to a concept by which newcomers acquire and expand their professional skills and knowledge, becoming experts in the field in which they work. Regardless of level of participation, types of participation are described using qualifying concepts: peripheral, full, and marginal (Handley, Sturdy, Fincham, & Clark, 2006). Members interact with the CoP little in Peripheral Participation. They participate periodically but don't fully engage in community activities. They seldom participate in the CoP's joint venture and may not understand or support the community's aims. Their repertory is limited, covering just a portion of the community's knowledge and practices.

However, "Full Participation" means active and dedicated CoP participation. Fully engaged members cooperate, interact, and show a strong feeling of belonging and passion. They fully support the community's aims and actively contribute to them. A deep understanding of the community's knowledge, resources, and practices informs their wide repertory, which they actively contribute to and profit from (Handley, Sturdy, Fincham, & Clark, 2006).

On the other hand, "Marginal Participation" entails occasional or peripheral involvement in CoP activities. They may participate intermittently and out of responsibility rather than interest in the community's aims. Their repertory shows just a partial understanding of the community's knowledge, and they may not actively contribute or draw from it. These different levels of participation in a Community of Practice show how people interact with and contribute to the community, from full involvement and alignment with its goals to peripheral and marginal participation.

Lave and Wenger (1991) emphasise involvement in social practice and social interactions as a primary predictor of PD in understanding about the good teacher. The notion of participation in teacher communities should support teachers' collaborative development and learning. According to studies, participation without engagement and collaboration with each other tend to not support teachers' practice. For example, Vangrieken, Dochy, Raes, and Kyndt's (2015) systematic review study revealed that deep level teacher collaboration enhances teachers' learning and practice through sharing, reflecting and mutual engagement. They explained deep-level teacher collaboration as an amalgamation of joint enterprise and sharing. The former refers to a common ground for accountability between participants focusing on content and classroom teaching. The latter provides teachers with common ground for practice with regards to how pedagogical practice are formulised. Kind's (2009a) UK-based research found that when trainee teachers collaborate with their more experienced colleagues, they deliver more effective lessons outside of their specialisation. To become an 'expert' in science teaching, teachers must first understand new knowledge and reflect on it, such as how students understand science and the problems they face as they practice. Kind (2009a) concluded that getting advice and engaging with experienced colleagues is critical to becoming an expert in teaching.

Lave and Wenger's (1991) initial account needs to be broadened further to understand how participation contributes to teachers' practice. No matter how experienced members are, participation and collaboration are essential for building effective teacher communities that promote teachers' personal, and professional characteristics. Researchers agreed that teachers' PCK and professionalism can be developed through PLCs (Bergqvist, Drechsler, & Rundgren, 2016; Gess-Newsome, Taylor, Carlson, Gardner, Wilson, & Stuhlsatz, 2017; Kind &

Chan, 2019). For instance, Nilsson's (2014) study explored the chemical concept of ion and how ions are formed with three experienced chemistry teachers. The study aims to investigate how participation in a learning study shapes and improves three teachers' PCK. When the teachers started to break down their CK by figuring out what was most , this helped them develop a clear understanding of the subject area, in terms of how their students understood it and how they understood it themselves, as well as how to teach it. For example, the teachers brought up 'occupied words' that could make it hard to understand a certain idea because the meaning of a word (like shell) changes depending on the situation. This makes a word harder for the students to understand when it was used in a chemical setting. By doing this reflective thinking and collaboration, participants started to connect content and pedagogy in new ways, which could help them build their PCK. , the teachers said reflection on students' misunderstandings through mutual engagement of each other's idea was a key part of how they learnt. The next section emphasises reflective practice as a crucial feature in explaining high-quality participation and deep level collaboration.

2.3.2 Teaching Practice: Reflection

Creating an environment in which teachers exchange ideas, learn from one another, reconsider their teaching techniques, and make changes to improve student learning outcomes is critical to the development of teachers' practice. Education and teacher learning by Dewey (1933) and Schön (1983, 1987) and Park and Oliver (2008) put reflection-in-action and reflection-on-action into central to interconnected components of PCK, based on Schön's (1983) work. The term 'reflection-on-action' refers to the way teachers use reflection to guide their teachings, or their everyday practice, which includes the lessons they teach and students' engagement. When preparing lessons and taking the growth of their students into account, teachers need to reflect on action. 'reflection-in-action' refers to teachers who reflect as they deliver their lessons or participate in PD programmes.

Practice along with reflection is required for self-awareness. Therefore, teacher development requires 'poiesis' and 'praxis'. The term 'poiesis' refers to making, while 'praxis' refers to doing (Wall, 2003). Therefore, to make something, a technical skill is necessary, called techne. To do something, 'phronesis', which refers to practical wisdom, is essential for appropriate judgement (Biesta, 2014; Biesta, 2015; Markus, 1986). From an educational perspective, concepts help understanding what is needed for a desirable education. In this sense, these ideas might refer to how to be a good person, a wise person and how to gain a moral character. Handley et al. (2006) emphasise ‘praxis’, which signifies meaningful interaction within teacher communities through reflection. Reflection cannot be manipulated, but is a continuous, social, and participatory activity. Reflection is revitalised when individuals collaborate to execute something in the present. It offers actors with resources for behaviour, but directs them to consistently behave. Reflection is the process of learning to perform something without completely comprehending why it is done or being able to communicate what is done in a meaningful manner. This section highlights why reflection is necessary for teachers to become great.

Reflection is an essential component of PD for improving teachers' practices and acting as a change agent (Clarke & Hollingsworth, 2002). Reflective practice should be creating meaningful interaction among teachers participating in learning communities. Antoniou and Kyriakides (2013) conducted an intervention study in Cyprus with 130 primary school teachers from government schools who participated in the PLC. This experimental study revealed that teaching quality depends on critical reflection, which encourages teachers to address their professional needs. The Dynamic Integrated Approach refers to “skills associated with direct teaching, such as structuring and questioning, and to skills associated with constructivist theories of teaching and learning, such as orientation and teaching modelling” (Antoniou &Kyriakides, 2013, p. 2).

Critical reflective practice is the most comprehensive and developed form of practicing teaching (Brookfield, 2017) and therefore crucial in effective teacher PD, resulting in changes to beliefs, identity, instructional practices, and knowledge. McArdle and Ackland (2007) aimed to connect ‘the workplace’ and ‘the learning community’, via critical discourse and critical reflective practice as a method of gaining awareness of the presence and nature of communities of teaching practice. Studies have found that encouraging thinking dispositions, that is, critical reflective practice, in participants may help to illuminate conflicts at the borders between learning communities and the workplace, resulting in knowledge relevant to the workplace.

Nilsson (2009) used the notion of 'critical incidents' through reflection to investigate student teachers' pedagogical reasoning in learning about teaching. Twenty-two elementary pre-service teachers who chose to teach chemistry or physics topics involved problem-solving and experimentation like gases, density in chemistry, experimentation with electricity in physics. The findings from the study showed that critical incidents linked to classroom management and students' attitudes and learning in science. For example, pairs of teachers came across unexpected circumstances while they were demonstrating how baking powder blew up balloons. Teachers prepared their answers 'why did balloon blow up?', yet no students asked questions. This prompted teacher to reflect on their instructions and teaching practice. This sharing process help teachers to reflect on the aim of experimentation in chemistry class. Nilsson (2009) concluded that sharing develops teachers' PCK once teachers reflect on their practice.

Improving teaching methods and student learning results are greatly aided by teachers' reflective processes. Understanding the context, content, and results of reflection is crucial, although some claims that it is useless in and of itself. The idea of "reflection-on-action" and "reflection-in-action," which draws from the writings of Dewey (1933) and Schön (1983, 1987) and Park and Oliver (2008) are essential to teachers' pedagogical content knowledge (PCK). 'Poiesis' (creating) and 'praxis' (doing), in addition to technical expertise and life experience, are crucial for self-awareness and successful teacher preparation. Since reflection is a social and interactive process, it is essential for meaningful communication within professional communities and promotes ongoing development. As a transformative component of teacher professional development, critical reflective practice brings about changes in knowledge, beliefs, identities, and instructional practices. Research emphasises the value of crucial events and experience-sharing in supporting PCK development in educators, highlighting the role of reflection in the process of developing into a successful teacher.

2.4 Teacher Professional Knowledge

PD programmes in countries that experience shortages of science teachers focus primarily on developing teachers' professional knowledge through subject-specific PD. Wallace & Loughran (2012) highlighted widespread consensus that science teachers' PD should concentrate on enhancing professional knowledge which, in turn, develops their teaching practice. This section discusses what kind of knowledge teachers need and why they need that knowledge. Additionally, in this section, the relationship between great teacher and knowledge is discussed.

The literature discusses a varied range of qualities that signify great teacher. For example, Wilson, Shulman, and Richert (1987) investigated what kinds of knowledge teachers need to have and how that knowledge can be transferred in a meaningful way to students. They considered SK to be a prerequisite for students' learning. If teachers themselves do not have a comprehensive grasp of the knowledge they are trying to impart, they cannot promote students' understanding of science (Ball, 1991). Carlsen (1993) addressed the similar issue with the participation of four novice biology teachers in a yearlong study, suggesting that if teachers had high SK in the areas they wanted to teach, they could construct more complicated and challenging questions about topics to teach better or test whether students comprehended the topics. Carlsen's (1993), Hashweh (1987) Sanders, Borko, and Lockard (1993) revealed a difference between knowledgeable and unknowledgeable teachers in terms of SK in science teaching. Teachers for higher education uses higher-level hinge-point questions to assess students' understanding and teachers depend largely on textbooks and want to remain in the safe zone.

Kind's (2014) study focused on teachers' specialised CK, which refers to a scientific knowledge and understanding of teachers to teach concepts and facts. Kind's study includes 265 pre-service teachers teaching 11- to 16-year-olds in the UK, with a focus on knowledge of mass conversation, chemical bonding, mole calculations, and combustion reactions impacts their understanding of those concepts. She found that teachers who lack high-quality chemistry CK may have difficulty understanding chemistry concepts such as chemical bonding, mole calculations, and combustion. Nixon, Campbell, and Luft's (2016) study searched how teachers' core, specialised and linked CK impact on teaching practice of conservation of mass and chemical equilibrium with six teachers. They noticed that teachers with good CK plan and organise lessons and ask more sophisticated chemistry questions than do those with weak CK. All these studies indicate that regardless of topics, sample size and context that teachers teach, SK or CK influences teachers' practice. The more knowledgeable and misconception-free teachers become, the greater their understanding of the scientific concepts and facts they teach, which impacts their teaching practices. Teachers usually put emphasis on CK as a means of improving teachers’ pedagogy with relation to classroom management and knowledge of students.

Which knowledge contributes to students’ learning the most is discussed. Coe, Aloisi, Higgins and Major (2014) categorised teacher quality components as having weak, moderate, and strong impact on student learning. They used meta-analysis in seven areas to identify weak, moderate and strong impact on students’ learning. Coe, Aloisi, Higgins and Major (2014) used seven methods for measuring teaching quality namely: classroom observations, value-added models, student ratings, principle judgement, teacher self-report, analysis of classroom artefacts and teacher portfolios. They found that teacher beliefs and professional behaviours have a weak impact; classroom climate and classroom management have moderate impact. The last two components—quality of instruction and PCK—generate the most impact on student academic achievement. Kind’s (2019) study showed how teachers’ CK influence on students’ meaningful learning. Data were collected from 239 pre-service teachers (who teach students aged 12–13) through three vignettes in chemistry, biology, and physics in England. Vignettes were designed to reflect students’ misconceptions and incorrect ideas about chemical reactions in chemistry, electric circuits in physics, and plant growth in biology class. According to the findings, meaningful learning occurs when teachers deliver high-quality CK and PK. When teachers demonstrate high-quality SK but lack PK, learning may occur, but it is not meaningful or rote learning. Finally, when teachers have high PK but have inadequate or incorrect subject understanding, students' learning is irrelevant or incorrect.

Rollnick, Bennett, Rhemtula, Nadine, and Ndlovu’s (2008) case study with three teachers teaching the concepts of mole and chemical equilibrium at a high school in South Africa investigated the relationship between SK and PK and how SK impacts students' understanding of the two concepts. Rollnick et al. (2008) found that teachers' limited knowledge made it difficult for them to connect conceptual and numerical components of the mole topic. Teachers with low SK, which refers to having misconceptions and poor understanding of concepts and facts and chose to teach the mole solely via algorithms, while teachers with high

SK refers to having a good integration and misconceptions free core, specialised and linked CK taught at the conceptual and algorithmic levels.

A detailed literature review examines the importance of SK and CK for teaching. While these knowledge categories are important in teaching, the studies emphasise the importance of PCK in meaningful student learning. Wilson, Shulman, and Richert (1987) demonstrate the importance of comprehensive SK for student learning. Kind's (2019) and Nixon, Campbell, and Luft's (2016) research further emphasises the relevance of specialised CK in helping teachers plan and organise lessons, ask smart questions, and help students understand complicated scientific topics. Emphasising SK and CK has limitations, too. Rollnick et al. (2008) case study shows that teachers' insufficient expertise can prevent them from connecting conceptual and numerical components, excluding crucial instructional insights. Coe, Rauch, Kime & Singleton, (2020) categorization of teacher quality components reveals that while SK and CK help students learn, PCK integration has the greatest impact on academic achievement. Thus, the findings emphasise the necessity to balance all three knowledge domains, with PCK connecting topic knowledge to effective pedagogical practices. This suggests that PD programmes should include SK, CK, and PCK to improve instructors' instruction and student learning. Future research might examine the tactics and frameworks in PD programmes that promote PCK, helping teachers bridge the gap between subject-specific knowledge and effective classroom pedagogy. This integrative approach can greatly improve teaching and learning.

2.4.1 Pedagogical Content Knowledge

Shulman (1987) proposed PCK as a 'special amalgam' of content and pedagogy. Shulman's PCK comprised instructional strategies, i.e., the techniques used by teachers to engage learners in meaningful learning and the knowledge of students' subject matter learning difficulties. This knowledge includes the misconceptions and learning barriers that may prevent students' learning concepts and ideas the teacher needs them to learn. Shulman did not propose a clear connection between the two components.

Grossman's (1990) model, which interconnected subject matter knowledge, general PK, and knowledge of context and put emphasise on instructional design of teaching. Grossman identified the role of CK in designing the curriculum. Grossman adhered to Shulman's original model in terms of categorising CK as external to PCK. Grossman taught that CK was part of a teacher's knowledge base. According to Grossman's model, PCK comprises four components: knowledge of students' understanding; curricular knowledge; knowledge of instructional strategies; and conceptions for teaching subject matter. According to Grossman (1990) found is a strong relationship between teachers' knowledge of content can improvise its presentation.

Grossman underlined elements of the knowledge base of teachers that Shulman (1987) had proposed and characterised PCK as transformative and generic. The development of PCK relates to teachers' experience and beliefs and depends on how knowledgeable preservice teachers are about the topic they teach. Mavhunga (2016) conducted a case study with 36 preservice teachers in South Africa about whether PCK is transferable from one topic to another by investigating 'particulate nature of matter' and 'chemical equilibrium'. They used content representations as a tool how teachers teach a particular topic. The goal of the intervention was to improve participants' capacity for conceptual change in the area of particle nature of matter (Mavhunga, 2016). The intervention has successful changed the way CK has taught which showed that the learned skills were successfully transferred.

Magnusson, Krajcik, and Borko's (1999) model, which is based on Grossman (1990) and Tamir (1988), remains popular in science education research. Magnusson et al.'s (1999) model includes knowledge of assessment as a component of PCK and substitutes 'orientations to teaching science for conceptions of purposes for teaching subject matter', extended through the notion 'which shapes'. According to them, a teacher's general approach to understanding how to teach science is referred to as their orientation to science teaching. Later, science teaching orientations were characterised as a set of beliefs by Friedrichsen, van Driel, and Abell (2010) as to how science can be taught in relation to the goals and purpose of science teaching. Based on Magnusson et al. (1999) and Friedrichsen et al. (2010), PCK is more associated with teachers' beliefs. Park and Oliver (2008) pointed out that teachers' PCK is idiosyncratic. They claim that 'teacher efficacy' is a sixth PCK dimension which plays a crucial role in integrating the other components with one another. Their remaining five components are: orientation to teaching science; knowledge of science curriculum; knowledge of assessment of science learning; knowledge of students' understanding of science; and knowledge of instructional strategies for teaching science. Park and Oliver's (2008) contribution shows that PCK has a cognitive dimension that is developed through reflection. Teacher efficacy contributes to growth of PCK. Students' misconceptions are a main factor that influence teachers' PCK.

Park and Chen (2012) contended on knowledge of students and understanding of instructional strategies, which improved students' learning. The stronger the link, the greater the influence on pupils' learning. Park and Chen's (2012) study mentioned that among components of PCK, knowledge of students (KSU) with knowledge of instructional strategies and representations (KISR), a teacher, for example, made eleven connections for photosynthesis but just four connections for heredity in teaching. Teachers' topic-specific instructional strategies bring about differences in connections across topics. This outcome was confirmed by Aydin and Boz (2013). They conducted research with two experienced chemistry teachers who teach electrochemical cells and redox reactions on the interconnection of PCK components described by Park and Chen (2012). According to the findings, knowledge of the learner and instructional approach components were critical to integration. Bergqvist et al. (2016) conducted a study on secondary school teachers in Sweden to investigate students' understanding on chemical bonding and found clear links between KSU and KIS for just two out of the ten teachers who utilised a topic-specific method like building models of molecules to help students comprehend chemical bonding.

PCK models proposed by important researchers like Shulman (1987) Grossman (1990), Magnusson, Krajcik, and Borko's (1999), Park and Chen (2012) demonstrate the importance of this knowledge in creating excellent teaching practices. According to Shulman's early PCK theory, knowing students' learning challenges and instructional tactics is essential to effective teaching. PCK is transformative and generic, and Grossman stressed the interconnectivity of subject matter knowledge, general pedagogical knowledge, and teaching methodologies. Studies by Mavhunga (2016) and Park and Chen (2012) have shown the complex interaction between students' comprehension, instructional tactics, and representations, which affects learning results. This shows how important PCK is in helping teachers make decisions and change their teaching methods to fit students' requirements. In addition, Park and Oliver

(2008) have illuminated PCK's uniqueness, with teacher efficacy becoming a key factor in PCK integration. According to the findings, teachers' reflective practices help them identify students' misconceptions and modify instructional tactics. The dissertation by Kind and Chan (2019) emphasises the importance of combining distinct PCK components to create relevant and successful teaching practices, echoing this holistic vision of PCK. This research examines the complex relationship between subject matter understanding, pedagogical strategies, and student knowledge to show how PCK can help teachers develop practical wisdom and improve student learning. The dissertation intends to contribute to the discussion on PCK's function in successful teaching and conceptual understanding in science education.

Kind and Chan (2019) followed Shulman's original idea with their critique of research that investigated ways in which PCK contributes to great teaching and to becoming a great teacher. Papers presented in the IJSE Special Issue (Neumann, Kind, & Harms, 2019) led Kind and Chan (2019) to offer a new structure for PCK in which the amalgam changes over time (see Figure 2.2).

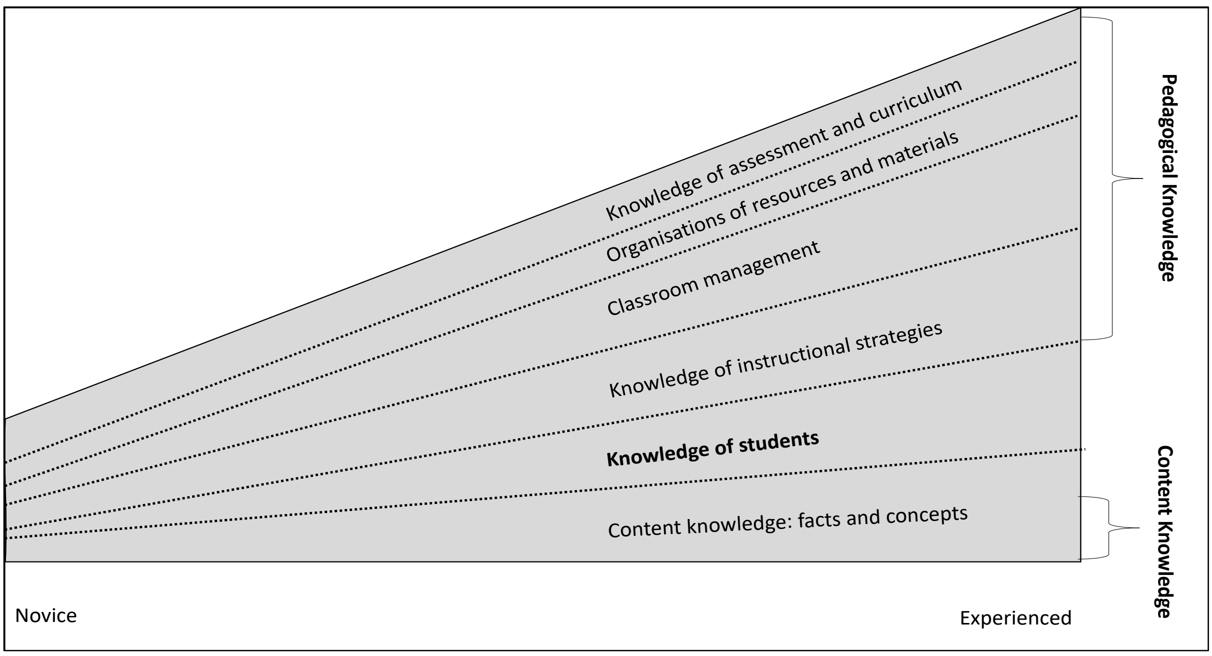


Figure 2. 2: Kind and Chan (2019): A new structure for PCK. Kind and Chan, 2019, p. 10

Figure 2.2 shows the Kind and Chan's (2019) conceptual model of the new structure for Pedagogical Content Knowledge (PCK), it recognizes the fact that PCK is an ever-evolving body of knowledge that changes as educators' progress in their professions. According to the model's temporal aspect, PCK is a construct that teachers continuously shape, develop, and adjust as they get experience in a variety of teaching scenarios. Understanding how PCK enhances teaching excellence requires an awareness of temporal development.

One can anticipate the integration of a number of PCK components inside the model, including knowledge of the content, knowledge of the students, and knowledge of efficient teaching techniques. When teachers travel through their professional journeys, these intertwined components impact and shape each other. For example, as educators gain a deeper understanding of the content they teach, their knowledge of successful teaching techniques may also grow, and they may be better able to modify their lessons to meet the unique requirements of their students.

Furthermore, the model probably emphasizes how various PCK components interact dynamically with one another. It emphasizes that PCK is a dynamic system whose components constantly inform and enrich one another rather than a static collection of separate knowledge (Kind and Chan, 2019). For instance, a teacher's understanding of students may influence their choice of teaching tactics, and the results of these strategies may then alter their understanding of both content and pedagogy. Understanding how teachers develop into outstanding educators requires an understanding of the dynamic interaction among PCK components.

The suggested conceptual model of the new PCK structure provides a novel viewpoint on PCK's development over time. Acknowledging the dynamic relationships among its components and its evolving character, this model offers a basis for investigating the intricate process of becoming a great teacher (Kind and Chan, 2019). The invitation to explore the subtleties of PCK's temporal development and its influence on pedagogical practices is extended to educators and researchers, with the ultimate goal of furthering the field's larger objective of improving teaching excellence.

Kind and Chan (2019) delve into the multifaceted concept of Pedagogical Content Knowledge (PCK) by examining its various subcomponents. The authors highlight the significance of instructional strategies, classroom management, organization of materials and resources, and knowledge of assessment and curriculum within the framework of PCK. By incorporating these essential elements, Kind and Chan shed light on the comprehensive nature of PCK and its implications for effective teaching practices. In addition, it is worth noting that within the realm of CK, facts and concepts are recognized as subcomponents. The interconnection between two distinct professional knowledge bases, namely PK and CK, is established through their shared understanding and expertise in relation to students. In addition, the present paragraph underscores the perspective that PCK is fundamentally a synthesis of CK and PK, as posited by Neumann, Kind and Harms, (2019).

This analysis acknowledges the importance of considering two specific components of PCK: the portrayal of Subject Matter Knowledge (SMK) and the utilization of instructional strategies. However, it is important to emphasize that these aspects still lack clarity and require further examination. In their insightful work, Kind and Chan (2019) astutely position the understanding of students' knowledge within a distinct realm that resides between PK and CK, thereby emphasizing its profound importance in the realm of teaching. The viewpoint expressed aligns with the ideas put forth by Shulman (1987) regarding the significance of understanding students' knowledge as a type of pedagogical reasoning that is essential for teachers to make informed decisions and engage in reflective practice in order to effectively meet instructional goals.

The significance of pedagogical reasoning in facilitating effective teacher-student communication has been acknowledged by scholars such as Geddis (1993) and Lederman, Gess-Newsome, and Latz (1994). These researchers emphasize the instrumental role that pedagogical reasoning plays in enabling teachers to effectively convey information to their students. Furthermore, the development of PCK among preservice teachers within their respective subject areas is also closely linked to the application of pedagogical reasoning (van Driel et al., 1998). This connection highlights the importance of pedagogical reasoning in enhancing the teaching abilities of future educators. In addition, the examination of students' existing knowledge on a particular topic has been recognized as a significant method of pre-teaching conceptualization (de Jong & van Driel, 2001; Halim & Meerah, 2002). In the realm of education, it has been widely acknowledged by educators that having a deep understanding of students' prior experiences and challenges is of utmost importance when it comes to shaping their instructional strategies. This recognition stems from the realization that such knowledge serves as a crucial foundation for effective instructional planning. By delving into students' past encounters and obstacles, teachers are able to gain valuable insights that inform their pedagogical decisions and enable them to tailor their teaching methods to better meet the needs of their students. This literature review aims to explore the significance of teachers' awareness of students' prior experiences and difficulties in the realm of instructional planning, shedding light on the various ways in which this knowledge influences teaching practices and ultimately enhances the learning outcomes of students. In their study, van Driel et al. (2002) emphasize the importance of educators being cognizant of potential obstacles that students may face, as this awareness enables them to adapt their instructional approaches accordingly.

Kind and Chan (2019) pointed out that as professionals, teachers make independent judgements and enact insightful decision-making. Great teachers comprehend what is effective in their classrooms and apply instructional strategies in particular situations. Teachers should have a high-quality PCK which leads them to decide what they should do or not to do in particular settings. van Driel et al. (2014) questioned the notion that having a broad knowledge of teaching strategies and found that it is not essential unless they result in meaningful learning. Therefore, van Driel et al. (2014) argue that PCK should not be recognised simply as a combination of CK and pedagogy as well as understanding of students' misconceptions. PCK alone does not make teachers great unless teachers' character virtues are imparted to their practice. Teachers are responsible for imparting virtues such as moral, intellectual, civic and performance to their students.

Kind and Chan's (2019) conceptual model of PCK and its subcomponents is a novel framework that shows PCK's dynamic and developing character. Their concept emphasises the interplay between PCK components including instructional methods, student knowledge, and successful teaching practices, emphasising their interconnection and continual improvement during a teacher's career. The dynamic relationships in the PCK model emphasise the reciprocal relationship between a teacher's understanding of students and their instructional strategies, emphasising PCK's relevance in effective pedagogical practices. The model shows how PCK transforms subject matter knowledge and pedagogical experience into a holistic view of the continuing process of becoming a skilled educator, emphasising its importance in developing teaching quality over time.

According to Kind and Chan's (2019) model, integrating PCK components like SMK and instructional strategies into the conceptual framework emphasises the complex relationship between these elements and teaching practices. Many researchers, including Shulman (1987), emphasise the importance of instructors' comprehension of students' knowledge in shaping their educational reasoning and decision-making. According to Geddis (1993) and Lederman, Gess-Newsome, and Latz (1994), pedagogical reasoning helps students learn meaningfully by improving teacher-student communication. Also stressed is the importance of teachers' character traits and beliefs in affecting their instruction. According to Kind and Chan (2019), a high-quality PCK may not be enough to make teachers effective; rather, they must integrate character virtues and moral principles into their pedagogical approach to create a holistic and impactful educational environment. Van Driel et al. (2014) argue that effective learning experiences require character qualities and the teaching of moral, intellectual, civic, and performance virtues. Thus, integrating PCK and professional values and virtues into teaching practice is essential to developing effective educators and providing meaningful learning experiences for students. This interwoven interaction highlights the intricate relationship between PCK and the development of a virtuous and powerful teaching practice, offering a compelling area for education study. The next section discusses how teachers' character virtues and beliefs influence their practice.

2.5 Professional beliefs and character virtues: A missing dimension

Professional beliefs and virtues (PB&Vs) influence teachers' beliefs, character strengths and teaching practice (Atkinson and Claxton, 2000; Biesta, Priestley, & Robinson, 2015). Dillon and Maguire (2011) discussed that being creative, imaginative, reflective, and innovative are qualities that teachers possess to teach their topics successfully. Atkinson and Claxton (2000) extended those qualities to personal decision-making, judgement and practical wisdom. The term professional beliefs refer to "teachers' perceptions, judgements, and decision-making and that motivate and drive teachers' action" (Biesta, Priestley, & Robinson, 2015, p. 624). Character virtues refers to positive personal strengths that promote individuals to address challenging issues with showing intellectual and moral sensitivity (Jubilee & Virtues, 2017).

The following discussion examines evidence from literature to explain and discuss the significance of intellectual, performance, moral, and civic virtues.

Arthur, Kristjánsson, Cooke, Brown and Carr (2015) conducted a three-year study with 546 teachers including student, newly qualified (NQTs), and experienced teachers and teacher educators in the UK. The data sets include semi-structured interviews and questionnaire. They found that the notion of 'the good teacher' is made up of six character strengths, namely fairness, caring (moral virtue), creativity, open-mindedness (intellectual virtue), love of learning (intellectual virtue), humour (intellectual virtue), perseverance (performance virtue), and leadership (civic virtue). Although their study did not include classroom observation, the findings from the study indicate teachers should have character virtues to be a good teacher. The following subsections discuss how these virtues support teachers to develop their practice.

2.5.1 Intellectual Virtues in Teaching Practices

Intellectual virtues include open-mindedness, creativity, curiosity and intellectual humility. Training students' creativity may contribute significantly to their flexible thinking and their ability to handle changes in their working lives. Kind and Kind (2007) pointed out, 'creativity' in the literature is associated with good teaching. The Trends in International Mathematics and Science Study survey (Beaton, Martin, Mullis, Gonzalez, Smith, & Kelly, 1996), reported that many teachers in most countries regard creativity as a contributor to success in school science. Teaching requires flexible and adaptable context-sensitive judgement in complex and ever-changing circumstances.

Open-mindedness is a component of teachers' practical wisdom. Taylor (2016) explained the relationship between open-mindedness and other intellectual virtues. Open-mindedness requires intellectual humility, intellectual courage and intellectual diligence, which play a significant role in the pursuit of knowledge and understanding (Whitcomb, Battaly, Baehr, & Howard-Snyder, 2017). Sharon and Baram-Tsabari (2020) put open-mindedness at the centre of science education. Salloum (2017) argued that it is the intellectual responsibility of teachers to identify students' misconceptions about abstract concepts in chemistry classes and provide various instructional strategies to clarify those misconceptions, which promotes students' meaningful learning. Salloum and Abd-El-Khalick (2010) carried out an ethnographic case study with three science teachers in Lebanon to observe how teachers' intellectual humility and open-mindedness promotes practical wisdom in inquiry-based classroom. When a teacher explained Ohm's law to grade 9 students, she did not simply let students know formula, but she wanted them to observe interrelation between conceptual and algorithmic representation of Ohm's law.

Furthermore, the study carried out by Lord (2015) focuses on the influence of open-mindedness on practical wisdom, particularly on the ability of groups to learn. The study reveals a strong correlation between "openness" and improved organisational learning, practical wisdom, highlighting the importance of open-mindedness as a key component of collective learning capacity—an essential component of practical wisdom. Though interesting, the research would benefit from a deeper investigation of the underlying mechanisms and more objective measures of open-mindedness.

The importance of open-mindedness in fostering intercultural communication competence (ICC) in short-term study abroad programmes is examined by Wang et al. (2022). The study stresses that open-minded learners typically perform well in experiential learning, which contributes to improved learning outcomes. It also finds a positive association between open-mindedness and ICC. Despite its value, the study relies heavily on self-reported measures of open-mindedness and has need to further investigate the underlying causes.

The studies such as Wang et al. (2022) and Lord (2015) agree that open-mindedness plays a critical role as a learning catalyst, with Lord (2015) stressing the importance of open-mindedness in organisational learning and Wang et al. (2022) highlighting its function in intercultural communication competency. Although every study has its own findings, taken as a whole, they support the notion that having an open mind is a critical quality that underpins practical wisdom. According to these studies, those who are open-minded generally perform better in terms of learning outcomes, whether they are in an organisational setting or while studying abroad. People who are open-minded are able to fully immerse themselves in new experiences, free from prejudice and receptive to different points of view. This openness—which is seen in open-minded learners—complements practical wisdom by promoting improved decision-making, flexibility, and problem-solving. It's essential to highlight, though, that both studies depend mainly on self-reported measures of open-mindedness, which may introduce biases and fail to adequately reflect the subtleties of this attribute. Furthermore, even while the studies show correlations, they don't provide much information on the underlying interpersonal and cognitive processes that mediate or moderate the connection between practical wisdom and open-mindedness. These results emphasise the significance of fostering an open mind among both educators and learners in the context of the current study. In order to improve teaching and learning outcomes, intercultural competency, and adaptation in organisational settings, practical wisdom can be developed on the basis of open-mindedness. For educators and learners to succeed in varied and dynamic educational environments, understanding and fostering open-mindedness are essential.

Teachers should provide authentic environments in which students can practice those virtues. Salloum et al, (2010) investigated how being open-minded and having empathy can motivate learning more about the subject, find ways to back up students' ideas, and teach them how to make arguments. When a teacher wants to explain the endocrine system, she creates an inquiry-based, argumentative classroom to talk about the science of falling in love. The teacher in this study told students to think about what 'love' means to them and talk about it. She wanted them to look into how emotions affect the body and how hormones and emotions affect each other. Students gave reviews of articles and made suggestions for experiments that could be done to learn more. They asked questions about love and talked about how some questions can be answered in ways that are similar to the articles and how others cannot. Students explained and defended their ideas and points of view. The teacher learned from what the students said and got better at leading presentations and discussions as a result. This study showed that the teacher's practical knowledge about how to get students interested in learning about the topics helped her develop new perspectives and instructional strategies (using the inquiry-based approach) to help students learn more through being open-minded, asking questions carefully, and having empathy.

Open-mindedness, originality, and curiosity are examples of intellectual traits that are essential to good teaching. The practical wisdom of teachers is based on being open-minded, which necessitates bravery, humility, and effort in the search for information. Encouraging student participation through authentic, inquiry-based contexts facilitates the development of these characteristics. Students are inspired to learn more by their teachers' flexibility and empathy, fostering deeper comprehension and critical thinking. Teachers cultivate intellectual humility by promoting active involvement and facilitating discussions. This helps students' perspectives and improves their learning experiences, fostering a dynamic and supportive learning environment.

2.5.2 Moral Virtues

Teachers are responsible for getting students to be knowledgeable, and for transmitting moral and ethical values as a moral agent and exemplar. Buzzelli and Johnston (2001) claimed that moral behaviour is needed as classroom interaction is inherently and inextricably moral. Teachers should present moral character traits such as fairness and empathy to all students (Arthur et al., 2015). Aristotle in the *Nicomachean Ethics* described teacher as a moral exemplar (Irwin, 1999). In this section, I discuss why teacher should have moral character and how it influences teachers' practice.

Various scholars, including Dewey (1997), Carr (1993, 2006), Campbell (2008, 2013) linked teaching profession to morality which plays a role in developing student-teacher interaction. *The Moral Dimensions of Teaching* (Goodland, 1990), along with *Teaching as a Moral Activity* (Hansen, 2001) emphasise teaching as a moral activity. A qualitative study performed by Joseph and Efron (1993) in the USA with 180 teachers revealed that teachers regarded their responsibility as not simply delivering knowledge, but cultivating moral characters. These studies show that the required knowledge base for teachers extends beyond subject matter expertise and pedagogical techniques. It is necessary for them to develop their own identities so that they can educate their students on how to be intellectually and morally great individuals. Lickona (1999) claimed that schools and teachers should be responsible for character education. And, "…to be a good teacher, one needs to be or become a certain kind of person: a person of good character who exemplifies commitment to the value of what they teach" (Jubilee & Virtues, 2017, p. 9). Tuff (2009) indicated that teachers have demonstrated the moral components of teaching like caring, courage, integrity and justice to over academic accomplishment. Dewey (1993) highlighted that the first aim of teaching ethics in science is to enable students to gain ethical sensitivity. A second aim of teaching ethics is to increase the ethical knowledge of students. The third of aim of teaching ethics is to improve the ethical judgement of students, while the fourth aim of teaching ethics is to make students better members of a democratic society. It stresses teachers' importance in developing students' morals and ethics as well as information. Scholars have linked teaching's morality to student-teacher relationships. Teachers are moral role models who teach fairness and empathy. The results show that effective teaching requires more than subject knowledge—it requires moral character to inspire students to intellectual and moral excellence. It also emphasises character education, where teachers must model excellent behaviour to help students develop holistically. Science ethics education improves students' ethical awareness, knowledge, and judgement and prepares them for democratic citizenship. This conversation highlights teachers' multiple obligations as moral actors, directing students in academic success, morality, and ethics.

Elbaz (1992) discussed the moral dimension of teachers' knowledge, examining how this contributes significantly to students' motivation when teaching. Elbaz found that caring for difference is essential. However, it's crucial to critically assess the generalizability of Elbaz's findings. The extent to which caring and moral qualities vary across different cultural and educational contexts should be explored. Additionally, the practical implications of caring for students should be scrutinized further, as it plays a critical role in shaping students' attitudes and motivation. A moral teacher has a heart and cares for their students (Tam, Heng, & Jiang, 2009). This notion encompasses caring about what each student really needs (Carr, 1993; Jackson, Boostrom, & Hansen, 1993; Sockett, 1993) are some of supporting studies indicate that great teachers care about their students and develop a quality relationship with them. Hence, student- interaction should be improved. A distinctive feature of Chinese ethics is respect for the problem, a respect which requires a practical and moral response along with ethical consideration. Hence, Confucius highlighted that character should be cultivated through virtue ethics (Radcliffe, 1989; Rothstein, 1966). Important cultural insights into the formation of teachers' moral traits are provided by the incorporation of Confucian ethics and the emphasis on character development through virtue ethics. Rothstein (1966) and Radcliffe (1989), highlight the significance of character formation as a strategy for raising morally upright people. The idea of moral educators is supported by these philosophical foundations, but it's essential to assess how applicable and flexible these ideas are in modern learning environments. Because of the increasing diversity and complexity of today's educational contexts, character development calls for a nuanced strategy that takes into account various value systems and cultural viewpoints.

These studies collectively highlight the significance of caring for students and the ethical dimension of teaching. A critical analysis underscores the importance of adopting a holistic perspective. Teaching isn't solely about imparting knowledge but also about nurturing the holistic development of students. This entails recognizing individual needs, understanding the diverse cultural and moral contexts in which teaching occurs, and fostering a deep sense of care and responsibility toward students' growth.

In the context of the current study, it's imperative to acknowledge that the development of practical wisdom in teachers doesn't occur in isolation. Instead, it is intricately connected to their moral and ethical dimensions. Practical wisdom entails making informed, ethical decisions and choices. Therefore, it is imperative that any educational framework aiming to enhance teachers' practical wisdom should consider these moral and ethical dimensions. It's not just about improving pedagogical content knowledge but also about nurturing the character, empathy, and moral awareness of educators.

A good teacher's practice is based on moral values, fostering students' motivation and overall growth. Studies highlight how moral role models such as teachers play in promoting equity and compassion. Building compassionate and encouraging relationships between students and teachers is an important part of the moral dimension of teaching since it helps students develop their moral consciousness and character. Including ethics in the classroom encourages a considerate and realistic attitude, which is consistent with Confucian virtue ethics. This important realisation emphasises how moral virtues play a significant role in influencing a teacher's effective and comprehensive educational practice.

2.5.3 Civic Virtues

Civic virtues are associated with a person's citizenship and help in their understanding of their links to and responsibilities within society (The Jubilee Centre for Character & Virtues, 2017). An individual exhibits civic virtues when he or she does what a citizen is supposed to do. In this respect, civic virtues typically relate to the performance of a role or the exercise of a certain skill. Putnam (2000) identified three civic virtues: active engagement in civic affairs, reliability to each other and mutual help between people. All are developed through social connections. This shows that teacher communities provide teachers with an environment where teachers practice these virtues.

Similarly, according to Dillon (2016) fostering a person's sense of social responsibility through the incorporation of environmental education is consistent with the development of civic virtues. Within teacher communities, civic virtues are promoted through mutual help and active civic engagement. Teachers are essential in helping students develop social responsibility and environmental awareness since they are civic leaders. Dillon's research highlights the significance of fostering an awareness of the environment in educational settings, stressing the mutual relationship between civic virtues, environmental education, and community involvement. Furthermore, the research of Russo-Netzer and Shoshani emphasises how teacher leadership programmes may mould teachers into positive change agents who are in line with the development of civic virtues in educational settings. Together, these results highlight the crucial role that teachers play in fostering environmental stewardship and civic participation among students, highlighting the significance of including environmental education into the larger framework of civic virtue formation.

Teachers’ leadership practice, a civic virtue, is socially constructed and seen as the outcome of continuous interactions among teachers, principals, school personnel, students, and the greater community, underlining the of social interactions for teachers (Weiss, 1990). Russo-Netzer and Shoshani (2018) investigated how a teacher leader programme in Israel have designed by the Israeli Ministry of Education that makes traditional teachers into leader teachers. Study employed 41 participants including teachers, principals and leader teachers who teach in stages (from elementary to high school) in Israel. Data were collected through interviews. The findings revealed that teacher leaders in the PD support other teachers to develop their leadership and instructional practices through meaning-making process. The meaning-making process includes motivation, shared repertoire and mutual engagement. Although leader candidates in the study found the process of being a leader teacher was ambiguous, overall, they highlighted that it would a great initiative to change Israeli teachers' learning culture and perspective to becoming a teacher.

In science teacher education, the cultivation of civic virtues is to understand 'Why should science be taught?' and 'What is the purpose of teaching science?' Longbottom and Butler (1999) established that the purpose of teaching science to all children is that it makes a significant contribution to attaining a democratic society. Roy Bhaskar pointed out that people in society become connected to each other through meaningful social networks; hence society and people's actions affect each other (Corson, 1991). Biesta (2009a) highlighted that a major function of education is socialisation. In terms of attaining a democratic society, which is one of the major aims of science education, Dewey (1990) paid attention to school as a place where democratic ideas are reflected. Biesta (2009a) explained a further function of education, i.e., the qualification function of education. In a research on the importance of scientific education in advancing democratic principles, Campbell (2017) found that educators play a significant role in fostering students' critical thinking and engaged citizenship. Through the incorporation of democratic ideas into the science curriculum, the study demonstrated how education may develop knowledgeable and involved citizens who can actively participate in democratic processes. Hence, schools or educational institutions are responsible for providing students with knowledge and skills. If the aim of science education is to change society into a better place for every citizen and to make them active citizens (Biesta, 2007; Biesta, 2009b), then every student might be persuaded to understand the nature of science to help them grasp ethical and moral values, which are common to great teachers.

Civic virtues cultivate a feeling of societal connectivity and responsibility and are essential to responsible citizenship. Dillon (2016) focus on environmental education is consistent with the cultivation of civic values among teacher communities, encouraging cooperation and civic involvement. Similarly, research by Russo-Netzer and Shoshani (2018) highlights the transformative potential of teacher leadership programmes in fostering genuine participation and shared practices. Campbell's study underscores the crucial role that educators play in fostering critical thinking and active citizenship in students within the context of science education. It also underlines the significance of incorporating democratic values into the science curriculum in order to produce citizens who are educated and involved. Together, these results highlight how important education is in fostering civic virtues and guiding students towards being morally upright members of society in a democracy.

2.5.4 Performance Virtues

Performance virtues are specific forms of behaviour that enable activation of the intellectual, moral, and civic virtues. Baird (1992) highlighted that teachers' attitudes, conceptions, behaviours and beliefs play a significant role in improving teaching practice. According to Baird, great teachers promote a more optimistic viewpoint on themselves and their profession. It includes demonstrating greater concern, dedication, and self-assurance. Therefore, developing one's teaching needs more than merely becoming familiar with more efficient teaching techniques. (Baird, 1992)

Teacher motivation for example is a significant performance virtue which plays a prominent role in delivering knowledge and instructions to students epinastically. Teachers' motivation and interest revolve around their instructional decisions and in turn students' achievement. Teacher's beliefs play a bridging role between the organisation of particular tasks and how those tasks should be conducted when teaching students (Nespor, 1987). Teacher's beliefs influence acquisition of knowledge, judgement, designing of contents, organisation of materials, and instructional strategies (Pajares, 1992). Nespor (1987) distinguished beliefs as a separate concept from knowledge. Four criteria were identified to separate beliefs from knowledge; these are: existential presumptions, alternativity, affect, and evaluative loading (Nespor, 1987). Kind (2015) investigated about the preservice science teachers' science teaching orientation and beliefs about science. Data from 237 qualified science teachers were collected through topic-specific vignettes and questionnaires. The findings even though all the participants were qualified scientists, many held naïve beliefs about science teaching, whereas few held informed or partially informed beliefs.

Bandura (1977) argued that teacher's self-efficacy beliefs influence and shape teachers' teaching and learning behaviours. His self-efficacy theory proposes that teachers' beliefs play a role in motivating them to prepare and use effective teaching practices. Multon, Brown, and Lent (1991) study examined the connection between performance virtues and teachers' self-efficacy views in the context of instructional strategies. According to their research, there is a direct link between teachers' self-efficacy views and their effectiveness in the classroom. Higher self-efficacy teachers were shown to be more engaged, motivated, self-assured, and persistent in their teaching strategies. It was shown that these attributes greatly influenced and enhanced their general teaching methods, which in turn produced better learning outcomes, more student engagement, and more efficient classroom management. The study emphasised how crucial it is to support teachers' self-efficacy beliefs in order to encourage good teaching practices and, eventually, create a more favourable and productive learning environment for students, while Kind (2009a) used a questionnaire survey with 71 trainee teachers and interviews with 12 trainee science teachers in England who have specialist science knowledge in chemistry, physics or biology from their degrees to investigate the extent to which SMK impacts on trainee science teachers' self-confidence. The study showed that even though trainee teachers had 'good' SMK, good teaching did not take place because of their lack of confidence. Self-efficacy determines how teachers use instructional strategies and how they approach their students (Mojavezi & Tamiz, 2012; Schiefele & Schaffner, 2015). Teachers lacking self-confidence struggle to implement new approaches and comprehend their pupils' behaviour. Zee and Koomen's (2016) review study revealed that teachers' sense of accomplishment, work satisfaction, and commitment, as well as students' academic adjustment, are positively correlated with teacher efficacy, as are patterns of teacher behaviour and practices linked to classroom quality. Park and Oliver (2008) conducted a multiple case study with three experienced chemistry teachers in the USA. They collected data through classroom observations, semi-structured interviews, lesson plans, teachers' written reflections, students' work samples, and researchers' field notes. The results from this study revealed teacher efficacy as a new affective component of PCK. Teacher efficacy is regarded as a link between understanding and enactment. Successful enactment has been found to increase teacher efficacy.

In conclusion, Sections 2.3, 2.4 and 2.5 suggest a great teacher is an amalgamation of teachers' professional knowledge like CK, PK, PCK, PB&Vs, intellectual, moral, civic and performance which can be fostered through social interaction (Figure 2.3).

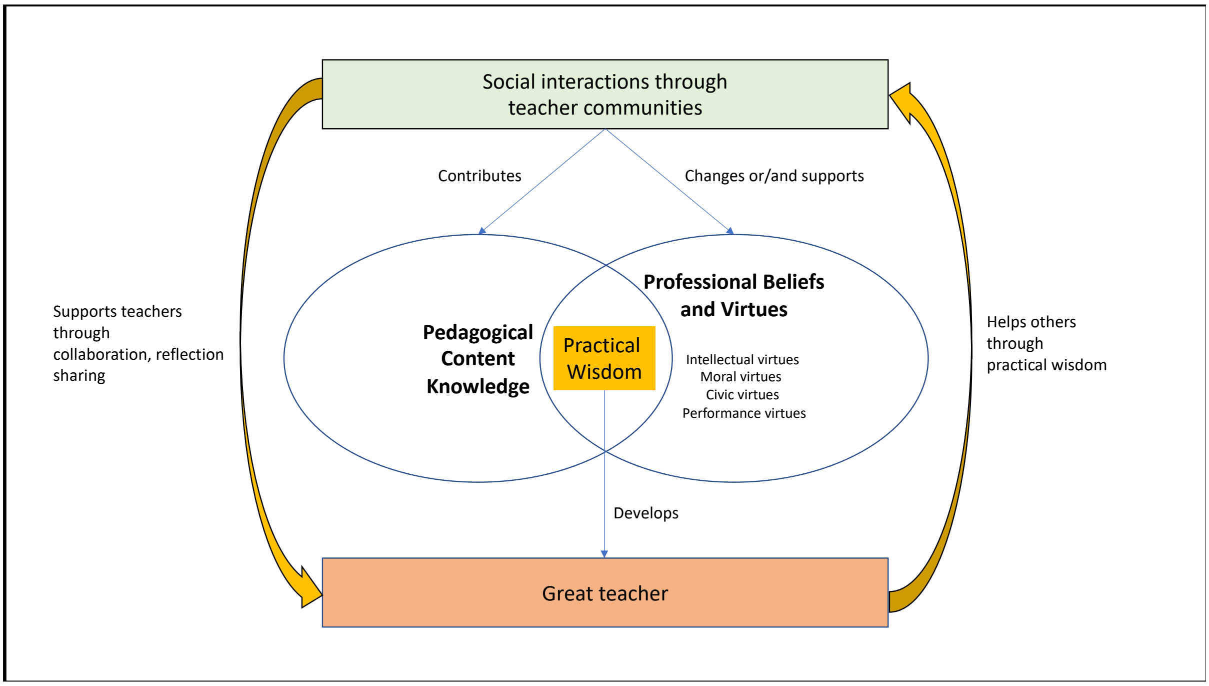


Figure 2. 3: The integration of PCK and PB&Vs for developing great teachers

Figure 2.3 suggests social interaction within teacher communities is essential in forming great teachers because they provide ways to integrate professional knowledge and PB&Vs, which are prerequisite for practical wisdom. Concentrating on knowledge bases for teachers such as CK, PK, and PCK undermines teachers' other characteristics such as educationally appropriate judgement, morals, ethics, civic responsibilities. A great teacher entails being educationally wise, acquiring practical wisdom for use with appropriate judgement, and acting as a wise decision-maker in any situation. Understanding practical wisdom is crucial to teacher education.

2.6 Wise Educational Judgement/Practical Wisdom

A great teacher cannot rely solely on their knowledge. The strength of the teacher's character that includes the teacher's intellectual, performance, moral and civic virtues, is a contribution. Having those virtues shapes teachers' professional knowledge, ensuring wise decision-making regardless of context. This section discusses why teachers need wise educational judgement/practical wisdom and how this impacts on practice.

The National Science Educational Standards (National Research Council, 1996) and the Next Generation Science Standards, 2013 (NGSS) highlight teaching practical wisdom ability, that is, an integrative virtue to enhance students' scientific reasoning and higher-order thinking skills. The U.S. Framework for K–12 Science Education (National Research Council, 2012) and the PISA 2015 Science Framework (OECD, 2016) pay attention to frameworks for enhancing students' meaningful learning and active engagement in science. According to Biesta (2015), knowledge, abilities, and reflection do not guarantee successful teaching practice. A way of encouraging teaching practice like reflection-in-action; knowledge, skills, and competence is to emphasise a *virtue-based approach* that leverages teaching practice as a catalyst for acquiring educational wisdom. Educational wisdom refers to "the embodied ability to make wise educational judgements about what is to be done, about what is educationally desirable." (Biesta 2015, p. 20). The virtue-based approach has the capacity to foster in-depth professional learning and develop lasting change in teachers' wise decision-making and judgements, which significantly adds to teachers' PCK and practice, and in turn students' meaningful learning.

Originating from the Greek word 'arête', the word 'virtue' generally refers to the moral and character excellence of an individual (Jørgensen & Nafstad, 2004). In *Nicomachean Ethics*, Aristotle argued that character excellence is fundamental in human excellence or for an excellence of soul; such excellence leads to eudaimonia, a term which is generally translated as goodness or human flourishing (Irwin, 1999). An understanding of how people incorporate new knowledge into existing knowledge and make sense of that knowledge lies at the heart of meaning-making and student learning. Schwandt (2005), for example, noted 'praxis' (refers to 'doing', 'action') as a practical knowledge. van Driel, Beijaarrd, and Verloop (2001) defied practical knowledge as ''the integrated set of knowledge, conceptions, belief, and values teachers' develop in the context of the teaching situation'' (p. 141). Practical knowledge, later, is linked to craft, which Aristotle called poiesis (refers to make something). Therefore, to make something, a certain technical skill is necessary, and it is called techne. Aristotle set phronesis (practical wisdom) apart from scientific knowledge (episteme) and skill (techne) (Biesta, 2014). Episteme leads to general principles that can be proven, but phronesis is needed to decide if a general principle is right for a given situation (Biesta, 2015).

Relatively few investigations focus on how practical wisdom presents in the classroom. An example is Salloum (2017), who explained the value of practical wisdom and its relevance to teaching science. He identified three aspects of practical wisdom that contributed to science teaching. Intellectual qualities such as critical thinking, creativity, and analytical thinking might be regarded as the foundation of scientific practices and characteristics of the nature of science. Cultivating intellectual virtues helps science teachers' pedagogical development and, as a result, their classroom actions. Finally, in terms of education in general, practical wisdom helps students understand the sociocultural nature of science and improves their personal interest (Salloum, 2017).

Good teaching is often related with competences and skills that teachers should possess. Biesta (2009a, 2014, 2015) noted that great teaching genuinely required 'judgement':

Good Teaching= Competence + Judgement

In chemistry education, which emphasises practical work for meaningful learning, teachers choose the goals and objectives of chemistry experiments, whether they are performed for fun or to aid students' comprehension of the subject. Wei and Lui (2018) studied a Chinese chemistry teacher with 30 years of experience to assess her practical knowledge of teaching. Only two metals' reactions with acid and water were in the textbook: the sodium (Na) and water reaction and the iron powder (Fe) and vapour reaction. Water interactions with potassium, magnesium, and aluminium were not investigated. According to the Metal Activity Sequence Table, the teacher chose K, Na, Mg, and Al to study their water and acid interactions. The teacher determined whether to add more elements to study metal reactions. At the secondary level, not all chemical topics can be taught using the inquiry method; others require direct instruction. Modeling is one of the most important instructional strategies used by teachers while teaching a subject. Student understanding, topic objectives, curricula, and textbooks all affect model selection. Demonstrations, visualizations, and narrative can also help students understand abstract chemical issues.

Practical wisdom is a useful character trait for chemistry teachers to acquire to determine what, why, and how chemistry topics should be taught. Many countries' science teacher education programmes, and chemistry teacher education policies in particular, pay inadequate emphasis to equipping chemistry teachers with practical wisdom. Biesta (2009a, 2015) offers multidimensional perspective to understand desirable education. These dimensions are *qualification, socialisation and subjectification*. Qualification refers to the ways in which teacher education institutes through universities in many nations educate pre-service teachers with the necessary information, abilities, and attitudes to perform their duties as professionals.

Biesta's (2009a) second dimension of education is socialisation. Socialisation refers to being part of a profession through participation to community-based practice where new pedagogies are learnt. The notion of CoP enables newly qualified teachers to engage with veteran teachers and make them good teachers. Being a good teacher requires more than training in fundamental skills and classroom procedures, as crucial as they are. It is a question of decision and diverse personal and professional judgments, as well as wisdom (Dillon & Maguire, 2011).

Biesta's (2009a) last dimension of being a good teacher is subjectification. Subjectification is the ability to make wise decisions, critical judgement and be accountable. According to Cooke and Carr (2014), practical wisdom (phronesis) is an ability to make a context-sensitive judgment in terms of what works in a particular context. To develop practical wisdom, it is essential to develop educationally wise judgement. Stenberg and Maaranen (2022) run a study in Finland with fifteen primary preservice teachers with a focus on promoting practical wisdom in teacher education. They examined the practicum experiences of primary school student teachers via their PPTs, which correspond to the pedagogical beliefs of teachers. The study revealed that high-quality teaching is supported or hindered when teachers translate their pedagogical beliefs into practice. Teachers' positive character strengths, including as fairness, approachability, passion, reflectiveness, and self-efficacy, have a positive effect on the development of practical wisdom. The nature of collaboration can improve all of those personal qualities (Stenberg & Maaranen, 2022). Those characteristics play an role in developing teachers' pedagogical beliefs and therefore practical wisdom.

Practical wisdom can facilitate building-oriented chemistry teaching, where teachers aim to develop critical, deliberate and action-competent citizens. Further, building-oriented chemistry teaching attempts to raise responsible citizens about socio-scientific issues (Sjöström, 2013). For this study among four nations, South Korea and, to some extent, Israel use pedagogies related to '*building-oriented'* chemistry teaching, that helps foster students' chemistry literacy.

Breier and Ralphs (2009) emphasise the value of communication and participation in developing practical wisdom. According to Schwartz and Sharpe (2010), learning and growth take place most successfully within communities of practice, and they also highlight the importance of collaborative environments in fostering practical wisdom. The process of self-reflection and professional growth is essential to the development of practical wisdom, as demonstrated by Korthagen, Loughran, and Russell's (2006) insights into how teachers evaluate and improve their teaching practices. The study adds to the body of knowledge by highlighting the value of professional development, reflective practices, and collaborative engagement in educational communities, ultimately fostering a deeper comprehension of the nature and implications of practical wisdom in the context of teaching and learning.

In the context of this research, practical wisdom is central to the study and acts as a guiding principle throughout. It is defined as the ability to use sound judgement when faced with complex real-world situations, with a focus on applied it in the field of education. Examining professional development, reflective practices, and practical participation within educational communities is made possible by the idea of practical wisdom. While Schwartz and Sharpe (2010) highlight the critical role played by collaborative situations in its development, Breier and Ralphs (2009) elaborate on the imperative of good communication and active engagement in cultivating practical wisdom. According to Korthagen, Loughran, and Russell (2006), self-reflection and professional development are inextricably linked to the development of practical wisdom, especially in the context of education. As this research develops, it highlights the ways in which these component parts work together to promote a better understanding of practical wisdom and its complex applications in the context of teaching and learning. In order to comply with the guidelines provided by the reviewing authorities and to significantly advance the body of knowledge in the field of education, it is imperative to develop clear definitions and maintain a firm commitment to the concept of practical wisdom.

2.7 Theoretical Framework

The utilization of theoretical frameworks within the realm of education is instrumental in elucidating and comprehending the complexities of pedagogical processes. One such framework that has gained prominence in educational scholarship is the Community of Practice (CoP) model. This framework, pioneered by Lave and Wenger (1991) and subsequently expanded upon by Wenger (1998), encapsulates a perspective that offers valuable insights into the dynamics of learning and knowledge construction within various professional contexts.

At the core of the CoP framework lies a distinct departure from conventional modes of knowledge transmission, be it in educational institutions or workplace settings. Traditional models often uphold the teacher-as-expert paradigm, where knowledge is conveyed from an authoritative figure to learners. In contrast, Lave and Wenger (1991) challenge this conventional wisdom by positing that learning is fundamentally an experience deeply rooted in the context within which it occurs. In this context, they assert that active members of a community come together, not merely to passively acquire knowledge but to actively construct and share it through practical engagement. This reconfiguration of the learning process is at the heart of the CoP framework.

Wenger's (1998) research on CoP further strengthens this theoretical foundation. His investigations were rooted in a study conducted within a call center, an office space primarily occupied by individuals engaged in administrative tasks. Notably, the practices observed in this setting were not explicitly documented in training manuals or formal policies. Instead, they organically emerged as a response to the specific needs, practical sensibilities, and creative problem-solving tendencies of the community members.

The theoretical contributions of Lave and Wenger (1991) and Wenger (1998) to the domain of learning theory are profound. They underscore the idea that, through active and participatory practices, learning communities naturally coalesce, thus coining the term "Community of Practice" (CoP). This framework, through its emphasis on communal knowledge construction and experiential learning, holds great promise for illuminating the development of exceptional educators.

This exploration of the CoP framework within the context of education is motivated by the desire to shed light on the cultivation of qualities that distinguish exceptional teachers. Qualities such as Pedagogical Content Knowledge (PCK), professional beliefs, virtues, and practical wisdom, which will be expounded upon in subsequent sections (2.5 and 2.6), are attributes that characterize great educators. Through the lens of CoPs, we aim to gain a deeper understanding of how these qualities can be fostered, nurtured, and refined in the pursuit of excellence in teaching.

In the following sections, I discuss social theory of learning, upon which is based on the CoP framework. Second, I provide characteristics of CoP, including mutual engagement, a joint enterprise and a shared repertoire. Finally, I explained why this study employs CoP as a theoretical framework, which have potential to generate great teachers.

2.7.1 The Social Theory of Learning

Social interactions between teachers result in changes in their teaching practice. According to social learning theory, learning occurs in social contexts through individuals' social relationships with one another rather than through individual endeavours (Marginson & Dang, 2017). Putnam and Borko (1997) argued that understanding how social interactions among individuals support meaning-making processes and create authentic learning environments is critical to understanding learning as a social practice. Vygotsky (1978) highlighted that participating in learning communities support teachers and develop teaching practice through collaboration with knowledgeable others. Lave and Wenger (1991) paid attention to social experience and interactions, which are critical to human progress and development, through what may be internalised sociocultural practices. According to social learning theory, learning occurs in social contexts through individuals' social relationships with one another rather than through individual endeavours (Marginson & Dang, 2017).

Carr (2005) stressed active participation and engagement among teachers in the community, which helps teachers advance their practice. In line with Carr (2005), Dewey (1997) stated that learning occurs if someone engages in meaningful activity; learning is a sociocultural matter rather than a natural development process.

This led me to question how teachers regardless of their experience learn from each other and gain perspectives to become a great teacher. This study explores the relationship between the notion of CoP and teachers' learning and teaching practice. Putnam and Borko (2000) accept that learning is social, which means that interactions with other people influence what is learned and how it occurs. By situating learning to teach around social participation, an effective CoP may develop through reflective practice among CoP members.

2.7.2 Characteristics of Community of Practice

Community of Practice (CoP) provide a useful framework for understanding the effects of reflective and collaborative learning on the practices of educators. Wenger, McDermott, and Snyder (2002) defined CoP as "a group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (p.4). Lave and Wenger (1991) considered the competent participant as someone who has and uses essential knowledge and abilities, and is a complete participant in cultural practices of the community. Lave and Wenger (1991) argued that membership and social interactions are foundations of participants' development and via social participation learning activities may be authentic and meaningful. Teachers have the chance to greatly expand their areas of knowledge in this setting. A better understanding of teaching strategies and subject matter is fostered by the interchange of ideas and experiences within a CoP, which helps members on their path to become excellent educators with a strong foundation in knowledge.

Moreover, CoPs benefit greatly from social engagement, which enhances the authenticity and significance of learning. Teachers may get practical wisdom and use their knowledge in real-world settings via their social involvement. Another essential component of CoP is problem-solving. Working together to solve common issues results in creative teaching methods, which in turn provide more potent tactics and, ultimately, excellent instruction. Last but not least, taking part in CoP helps teachers develop a strong connection with the cultural norms and unique character of the school community, which empowers them to adjust and move across this terrain with knowledge.

Wenger (1998) extended Lave and Wenger's (1991) perspective on CoP and added three characteristics which make CoP effective, namely, mutual engagement, joint enterprise, and a shared repertoire (Wenger, 1998). Doing meaningful activities together and acting together as a group to solve problems and generate new ideas are central to mutual engagement (Rogers, 2000). "Members define themselves through mutual engagement as well as their role in the engagement towards community and develop a peculiar way of participating through undertaking specific responsibilities in joint enterprise" (Meijers & Hermans, 2018, p. 190). Joint enterprise refers to the shared values or common goals that let teachers think together to enhance their teaching (Wenger, 1998). The last dimension, shared repertoire refers to "particular shared resources derived from participants' mutual engagement in the CoP" (Gau, 2016, p. 2). To shape shared repertoire, teachers are mutually engaged and produce joint enterprises through reflection with more competent others (Lesh & Lehrer, 2003).

After Wenger (1998) stressed the characteristics of CoP, researchers focused on how novice workers become full participants and gain skills and knowledge. For example, Fuller and Unwin (2003) investigated how newcomers become old-timers under the modern apprenticeship programme in the contemporary UK workplace. Evidence from three companies that used an apprenticeship approach to develop their newcomers' learning showed that learning experiences of new workers settled on the continuum between the expansive and restrictive characteristics of apprenticeship. The expansive participation refers to participation in multiple communities of practice, access learning fostered by cross-company experiences, plan time off-the-job for reflection. This participation provides workers with opportunities to develop their craft skills, knowledge, and vocational qualifications through mutual engagement between communities, shared repertoire and joint enterprise. Fuller and Unwin's (2003) study showed apprentices' participation and learning processes should be supported by formal education institutions. This is not covered in Lave and Wenger's (1991) perspective on newcomers' learning. Other researchers overcome this constraint by concentrating on workplace pedagogy and the development of supportive tactics and settings (Engeström, 1994; Fuller & Unwin, 2003; Hodkinson & Hodkinson, 2003, 2004).

Teacher education includes opportunities for teachers to gain pedagogical benefits of participation in CoP built on collaboration, interactions, sharing, and reflective practice within and outside school settings (Loughran 2014). Blonder and Vescio (2022) argued newly qualified teachers engage in PD activities and are members of several organisations and teacher communities throughout their careers to develop their teaching practice. Building a CoP does not necessarily ensure a shift in teaching practice. Supovitz and Christman (2005) discovered that communities that affect teacher practice should concentrate on reflective practice and provide them with opportunities for mutual and equal learning. Akerson, Cullen and Hanson (2009) investigated how communities of practice influenced elementary school teachers' understanding of the nature of science (NOS). They found that the CoP alone was insufficient to modify teachers' practices and knowledge. When teachers shared their knowledge, experience, and resources with one another about NOS, it generated a well-supported atmosphere that aided teachers in changing practice.

The study conducted by Hodkinson and Hodkinson (2003, 2002) play a crucial role in illuminating the complex dynamics between individual attributes, communities, and the wider educational context. In their thought-provoking study, Hodkinson and Hodkinson (2003) delve into the fascinating realm of personal dispositions. They argue that these dispositions, which encompass learning, work, and career orientations, undergo a transformative journey shaped by life experiences and interactions within one's unique learning trajectory. The author's perspective eloquently highlights the profound impact that character virtues and beliefs have on an individual's journey towards professional growth. This analysis offers a valuable perspective on the topic of teacher professional development (PD). However, it is essential to thoroughly scrutinise the methodology, potential biases, and generalizability of the findings in order to fully assess their validity.

In their relevant exploration of four subject teaching departments, Hodkinson and Hodkinson (2002) present a noteworthy contribution to the understanding of communities of practice. The authors' examination of secondary school teachers in England adeptly highlights the profound impact that collaborative environments can have on individuals. The researcher's methodology, particularly their choice of case study subjects and data collection techniques, warrants a thorough critique in order to assess the relevance of their findings within a wider educational framework.

The studies' inherent value to the dissertation is evident in their ability to enrich the theoretical foundations and practical implications of the research. Hodkinson and Hodkinson (2002) examination of character virtues and beliefs, along with their exploration of collaborative communities, presents a thought-provoking foundation that demands careful evaluation to determine its alignment with the research objectives of the dissertation. Moreover, through a meticulous examination of the studies, one can identify their merits and drawbacks, thus enriching our comprehension of how these discoveries can be relevant within the particular research framework. The evaluative approach employed here effectively ensures a seamless integration of these studies, aligning them perfectly with the overarching goals of the study.

Communities of Practice (CoP) and Professional Learning Communities (PLC) are two models that have significant value in facilitating collaborative learning and fostering professional growth within educational settings. Nevertheless, the decision to choose for Communities of Practice (CoP) instead of Professional Learning Communities (PLC) is often influenced by the prioritisation of certain essential attributes and their congruence with the changing requirements of educators.

CoP is founded on the principle that persons who possess a common interest or concern unite in order to enhance their understanding and proficiency via continuous contacts (Hodkinson and Hodkinson, 2003). The methodology presented emphasises the emergence of expertise via spontaneous and grassroots processes, hence promoting a more adaptable and learner-centred approach. In the context of a CoP, the primary emphasis is in the communal endeavour to acquire knowledge and comprehension, hence fostering the professional development of educators. The aforementioned phenomenon fosters the interchange of varied perspectives and personal encounters, beyond the confines of established institutions. The significance of inclusion is especially noteworthy in the current period characterised by a wide range of educational environments and the fast evolution of teaching techniques.

On the other hand, it is common for PLCs to possess an institutional framework and exhibit a greater level of inflexibility in their methodology, characterised by pre-established objectives and professional development endeavours. Although PLCs possess advantageous qualities, their hierarchical structure and the possibility of imposing rigid directives may restrict the genuine development of professionals. On the other hand, CoP facilitate a more natural interaction among educators, leading to a comprehensive comprehension of teaching methodologies and a stronger feeling of responsibility towards their professional growth.

In summary, the decision to choose the CoP framework instead of the Professional Learning Community (PLC) is motivated by its prioritisation of organic, collaborative, and learner-centric approaches to professional development. This method is more suitable for the dynamic and diversified educational environment, enabling educators to adapt and flourish in their continuously changing duties.

2.8 Conclusion

I propose a 'teacher quality framework' model which might have potential to develop teachers' learning and incorporate into practice, and student learning (Figure 2.4).

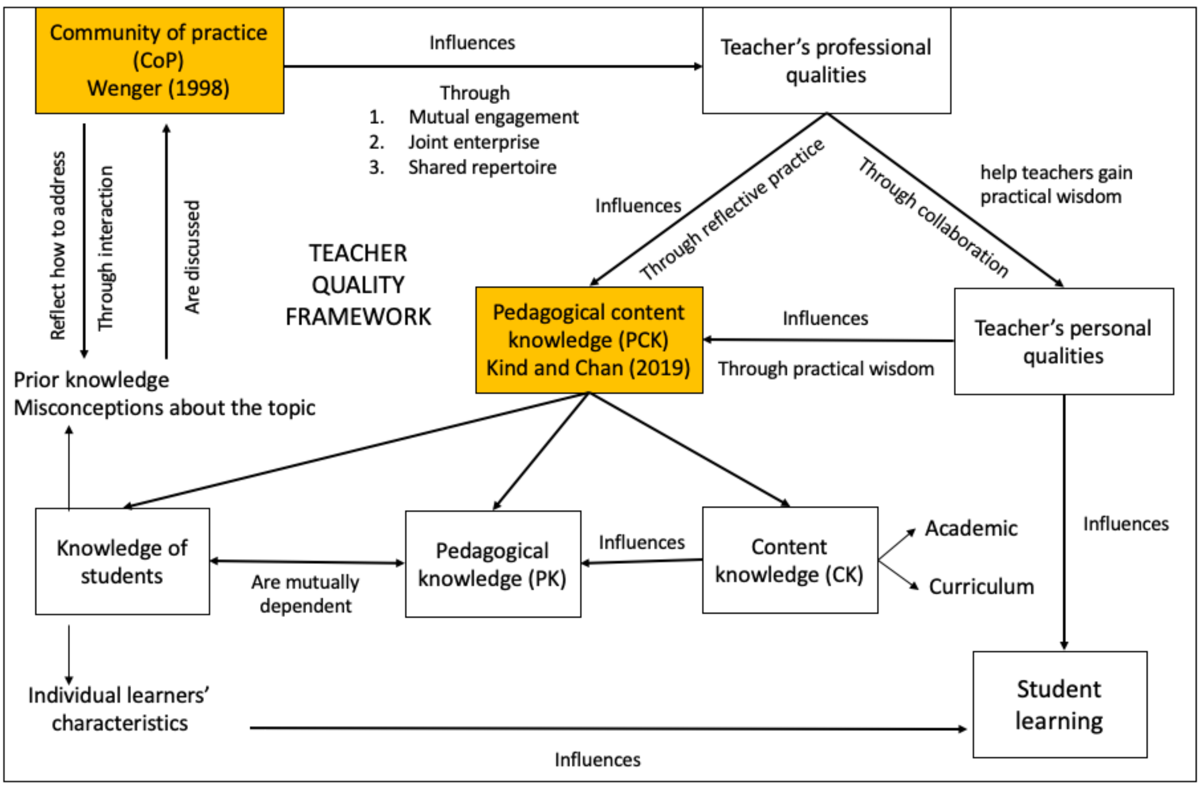


Figure 2. 4: Teacher Quality Framework

The "Teacher Quality Framework" model has the potential to dramatically improve teachers' learning and its application in practice when combined with the idea of a CoP. Many different aspects of a teacher's professional qualities may be significantly impacted by this integration, which may then have an effect on PCK and, eventually, student learning. This integration, which draws from Kind and Chan's (2019) insights and takes into account the interplay of teachers' personal qualities, can foster a more comprehensive understanding of the shift from PCK to CK, PK, students' knowledge, and the ways in which these elements relate to prior knowledge.

A variety of teacher qualities, competences, and traits are included in the "Teacher Quality Framework," which functions as a structured model. A dynamic platform for teachers to engage in collaborative and experiential learning is created when these components are thoughtfully connected with a CoP. Teachers in a CoP develop deeper professional qualities by actively participating in the creation and exchange of pedagogical insights rather than just receiving knowledge.

"Teachers' professional qualities" in the context of education refers to characteristics that are closely associated with classroom competency. These include topic knowledge, pedagogical understanding, classroom management skills, flexibility, effective evaluation, and a dedication to professional growth. On the other hand, "Teachers' personal qualities" refers to the unique values, virtues, and beliefs that each teacher possesses and how these impact their teaching. These include effective communication, patience, empathy, and dedication. A thorough and effective teaching practice is produced by the fusion of these personal and professional qualities, resulting in a positive and fruitful learning environment (Kind and Chan, 2019).

The development of a teacher's professional qualities may become more comprehensive because of this integration. By drawing on their experiences and insights into the needs and prior knowledge of their students, teachers might, for instance, improve their PCK through interactions within a CoP. In addition to fostering the development of strong pedagogical reasoning and the cultivation of practical knowledge, the CoP environment fosters the exchange of successful instructional strategies.

The importance of both PK and CK in successful teaching is emphasized by Kind and Chan (2019). The integration of PK and CK is aided by a CoP through the exchange of instructional expertise and subject-specific knowledge. This enhances teachers' prior content knowledge (PCK) by enabling them to link subject matter knowledge with pedagogical strategies that align with the distinct qualities and background knowledge of their students.

In this framework, the personal qualities of the teacher also hold great significance. A CoP can foster and refine personal qualities like empathy, adaptability, and reflective practice, which will improve a teacher's ability to recognize and address the needs of each individual student.

Student learning results are anticipated to considerably improve when teachers' PCK matures and their professional qualities develop. Tailored and successful training is built on the coherent relationship between students' past knowledge, PCK, PK, and CK, and their existing knowledge. It enables teachers to design learning experiences that are attentive to the unique needs and prior knowledge of their students, in addition to being guided by their extensive knowledge.

Consequently, the potential to create a rich environment for teacher learning and development lies in the integration of the "Teacher Quality Framework" model with a CoP. The professional qualities of teachers such as subject expertise, pedagogical knowledge, classroom management, adaptability, effective assessment, and continuous professional development are influenced by this integration, which also has an impact on PCK and eventually student learning. It provides a methodical way to move from PCK to PK, CK, understanding of students, and a nuanced understanding of the function of prior knowledge in the teaching and learning process.

Chapter 3: Education Systems of the Four Case Study Countries

"Quality education is dependent on context and, therefore, it may take many forms worldwide".

-UNESCO, 2004, p. 36

3.1 Introduction

Document and thematic analyses were conducted to determine how the quality teacher framework (see Chapter 2) is reflected in international teacher education policies. Section 3.2 explains the rationale for selection of the four case countries. Section 3.3 and Section 3.4 explains how document analysis and thematic analysis were conducted. Section 3.5 gives information about country-specific document analysis. Section 3.6 provides the results for the document analysis. Sections 3.7, 3.8, 3.9, and 3.10 outline the four nations' education systems. Section 3.11 explains conclusion.

Within the framework of this study, document analysis is a crucial methodological component (Mackieson, Shlonsky, & Connolly, 2019). Its main goal is to illuminate the subtleties of teacher knowledge and educational systems in the context of the four chosen case study nations. The objective is to acquire a more profound comprehension of the norms, guidelines, and procedures that support these educational systems via the scrutiny of several pertinent papers. This methodical technique accomplishes two goals. First of all, by providing actual data to evaluate the conceptual foundations laid forth in the earlier chapters, it helps to validate and improve our theoretical framework. Second, it serves as the foundation for intelligible comparisons between these various educational environments (Kokshagina & Keränen, 2022). Essentially, the document analysis serves as a means by which investigate and validate the theoretical frameworks, so enhancing the academic conversation around teacher quality and educational systems.

Kind & Chan (2019) PCK model was used for this study because to its compatibility with the main theoretical framework. The well-known theoretical construct of PCK offers an organised lens through which to look at how pedagogy and subject knowledge interact in the context of teacher quality. In order to use this model successfully, start by providing a brief but thorough synopsis of its main elements. This requires explaining how PCK creates a distinct field of knowledge that is necessary for efficient instruction by combining subject matter expertise with pedagogical experience.

During the document analysis stage, the Teacher quality framework (Chapter 2) model is used. It examine the numerous documents via the prism of PCK, classifying and analysing the data with an emphasis on the interactions and manifestations of instructors' pedagogical techniques and subject matter knowledge within the context of the case study nations' educational systems. By using the PCK model as an analytical tool, it is ensured that the document analysis is a purposeful investigation of teacher knowledge within the particular context of pedagogy and content knowledge, rather than a passive activity(Kokshagina & Keränen, 2022). This PCK model integration strengthens the study's conformance to the theoretical framework and offers a methodical way to extract insightful information from the documents.

3.2 Rationale for the Selection of the Case Study Nations

In comparative educational research, choosing case study countries is a crucial step that requires careful evaluation of many aspects to guarantee the study's applicability, representativeness, and efficacy. England, Israel, South Korea and Turkey are the case study nations selected for this investigation of teacher professional development (PD) and its effects on teachers' practices. These countries were chosen for PD and teacher practices due to a number of important factors, including as their various educational systems, their stature in the global education arena, and their capacity to provide insightful information.

3.2.1 Diverse Educational Systems

The choice of these four case study countries— England, Israel, South Korea and Turkey—is underpinned by their rich and diverse educational systems. Each nation encapsulates a unique educational context, characterized by distinct approaches to teacher preparation, curriculum development, and pedagogy. Within the Turkish educational landscape, an array of bespoke pedagogical approaches takes precedence (MoNE, 2017; Tekin, 2021). The strategies for teacher preparation, curriculum development, and pedagogical practices in Turkey reflect specific considerations and objectives that distinguish it from the other case study countries (Eris & Kiliçoglu, 2019; MoNe, 2022).

South Korea, globally renowned for its relentless pursuit of educational excellence, stands as an exemplar of a well-regarded educational system (Baek, 2019; Darling-Hammond et al., 2009). Teacher preparation, curriculum development, and pedagogical methodologies in South Korea play a pivotal role in the nation's educational success and distinguish it within the group of case study countries (KEDI, 2017; Kupaysinovna, 2021).

In contrast, Israel's educational system mirrors a captivating tapestry woven from a blend of cultures and historical epochs. (Ben-David & Kimhi, 2017) Teacher preparation, curriculum development, and educational policies in Israel bear the imprint of this rich cultural diversity, rendering it a distinctive case study in its own right (Donitsa-Schmidt & Ramot, 2020; RAMA, 2017).

In England, a juxtaposition of tradition and reform characterizes the educational system. Teacher preparation processes, curriculum design, and pedagogical methods are intricately interwoven within this context, thereby setting England apart as a distinctive case study among the selected nations (Donnelly & Brown, 2022).

The reasons behind choosing England, Israel, South Korea, and Turkey as case study countries are based on where each country falls on the educational development spectrum, as described McKinsey (2010). With this classification, educational systems are divided into four groups, ranging from "poor to fair" to "great to excellent." Aligned with the study's focus on teacher development, practical wisdom, and attaining 'excellent' teaching outcomes, England, which falls into the 'good to great' category, demonstrates a dedication to improving the quality and efficacy of its educational system. With deliberate efforts to improve its educational system, Israel is making the transition from "fair to good" to "good to great." This makes it a compelling case study for investigating the role of practical wisdom in teaching quality. In line with the study's emphasis on practical wisdom, South Korea, which falls into the "great to excellent" group, places a high priority on educational achievement. As it transitions from "fair to good" to "good to great," Turkey offers an insightful framework for examining the ways in which practical wisdom advances teaching quality in changing educational systems. This selection guarantees a thorough and varied investigation of the function of practical wisdom in many educational contexts (McKinsey, 2010).

By examining these diverse educational systems, this research aims to afford a comprehensive understanding of the influence of teacher professional development within each country's distinct educational landscape. The delineation of contrasts and commonalities across these systems is poised to offer valuable insights into the effects of teacher professional development in various educational contexts.

3.2.2 Prominence in International Education

In the selection process of these case study countries England, Israel, South Korea and Turkey—a pivotal consideration was their prominence in the realm of international education. These nations serve as focal points for comparative education research due to their active engagement in educational reform efforts.

The choice of countries for this study gains significance in light of McKinsey (2010) report, which underscores the pivotal role of educational policymakers in setting national educational priorities. International assessments like TIMSS and PISA heavily influence these decisions. For instance, South Korea's consistent top-ranking in PISA and TIMSS reflects its highly regarded educational system. England aspires to reach higher levels of performance, whereas Israel lags behind England. Turkey, in turn, trails behind Israel. These rankings serve as roadmaps for education policy, highlighting diverse priorities and emphasizing the substantial influence of international assessments in shaping educational trajectories (McKinsey, 2010).

Given their worldwide renown, these countries are exceptionally well-suited for a comparative study. Their collective experiences bear the potential to contribute significantly to international dialogues surrounding professional development for educators and its far-reaching implications.

3.2.3 Potential for Valuable Insights

The selection of case study countries— England, Israel, South Korea and Turkey—has been methodically based on their inherent potential to offer profound insights into the nexus between professional development for teachers and their teaching practices. Each of these countries represents a unique educational context, characterized by distinct approaches to teacher preparation, curriculum development, and pedagogical practices (Korolova & Popova, 2021; OECD, 2018). Turkey, for instance, showcases a tailored pedagogical approach (Gözüm & Kalogiannakis, 2022; Odabasi, 2014), while South Korea's pursuit of educational excellence sets it apart (Kupaysinovna, 2021; Park & So, 2014). Israel's unique cultural tapestry significantly influences its education system (Donitsa-Schmidt & Ramot, 2020; Azulay et al., 2013), and England presents an intriguing blend of tradition and reform (Ball, 2021: DfE, 2022). The aim of this study is to provide a comprehensive understanding of the intricacies and complexities surrounding teacher professional development within these distinct contexts.

3.2.4 Variety in Policy Approaches

The range of policy options for professional development for teachers is another consideration in the selection of these case study countries. England, Israel, South Korea and Turkey each have their unique policy landscapes that impact teacher professional development and instructional practices (DfE, 2018; Hilel & Ramirez-Garcia, 2022; Kokshagina & Keränen, 2022). These varying policy approaches offer an opportunity to explore the effects of different techniques on teacher professional development, enriching the knowledge base for educational policymakers and practitioners.

In examining teacher development and the cultivation of exceptional educators, the chosen nations reveal diverse policy approaches. England's implementation of Multi-Academy Trusts fosters collaboration and resource sharing among schools, impacting professional growth (Bernardinelli, Rutt, Greany, & Higham, 2018; Simon, James, & Simon, 2021). Israel's emphasis on "pedagogical horizons" encourages teachers to explore innovative teaching methods, enhancing their effectiveness (Donitsa-Schmidt & Ramot, 2020; Zohar, 2008). South Korea's focus on "master teachers" and "strong professional communities" cultivates a culture of mentorship and collaboration, contributing to teacher excellence (KEDI, 2016; Kupaysinovna, 2021). Turkey, with its more traditional approach, seeks to learn from other nations, showcasing a willingness to adapt and evolve (Tekin, 2021). These policies play a pivotal role in shaping teacher development and the pursuit of great teaching, each with distinct impacts on educational landscapes.

3.2.5 Contribution to Global Educational Discourse

The selection of these case study nations is consistent with the objective of advancing the global educational conversation on teacher professional development and how it affects teacher practices. The study attempts to provide light on the complicated relationship between teacher preparation and classroom practices by integrating nations with diversified educational systems, varied policy approaches, and worldwide importance. In addition to being beneficial for the chosen countries, these insights may be used as a guide by other nations looking to enhance their educational systems. The comparative aspect of the study facilitates the exchange of knowledge across national boundaries and the discovery of best practices that may be universally adapted and implemented.

The choice of England, Israel, South Korea and Turkey as case study nations for this comparative analysis is underpinned by the diversity of their educational systems, their prominence in international education, their potential to provide insightful information, the variety of policy approaches they encompass, and the aspiration to make a meaningful contribution to the global educational discourse. For example, England has always been at the forefront of education, and its sophisticated educational system puts it in a strong position to influence international affairs (Ball, 2021). Its continuous efforts to improve teacher professional development and the pursuit of "great" teaching results have produced insightful findings that have influenced global conversations on the efficacy and quality of instruction (DfE, 2010). The experiences of England are used as a model by other countries looking to change their educational systems.

Israel's rich historical and cultural background provides a unique viewpoint in the international discourse (Tal, Herscovitz, & Dori, 2021). The nation's distinct legacy is intricately entwined with its educational landscape, offering insights into the ways in which cultural elements influence educational practices and regulations (Reingold, 2022). The global educational community can learn important lessons about contextualising educational changes by looking at Israel's efforts to include practical wisdom into its teaching techniques.

South Korea is a global leader in education and is renowned for its incredible educational revolution. Its accomplishments of excellent teaching and learning results make a substantial contribution to the discourse on best practices in education (Kupaysinovna, 2021). The path taken by South Korea serves as an inspiration for other countries aiming to bring their educational systems up to par.

Turkey is an example of a dynamic educational environment that is undergoing change, reflecting the opportunities and difficulties that growing countries encounter. Its attempts to move from "fair to good" to "good to great" can teach other countries at similar developmental phases a lot. Turkey's experiences and goals add to the international discourse on teacher professional development and education reform (Çelik, Yurdakul, Bozgeyikli, & Gümüş, 2018; MoNE, 2017).

Together, these countries provide a varied range of experiences, policies, and practices that highlight the complex interactions between global educational policy and teacher professional development, adding depth and diversity to the discussion of education around the world (Kokshagina & Keränen, 2022; Schleicher, 2016). These countries' diverse array of experiences and contexts underscores the intricate interplay between teacher professional development and educational policies and practices on a global scale.

3.3 Document Analysis

The rationale for document analysis lies in its role in *“Methodological and data triangulation, the immense value of documents in case study research, and its usefulness as a standalone method for specialised forms of qualitative research” (Bowen, 2009, p. 29).* Hence, document analysis is coupled in this research with interviews and observations as a means of triangulation (Denzin & Lincoln, 2011).

Furthermore, the purpose of the document analysis was to delve into a comprehensive review of a selection of documents that were sourced to provide valuable insights into educational policies, practices, and innovations related to teacher development and teacher professionalism in the selected countries. This analysis centered on understanding successful implementations of these policies, which are essential for enhancing the quality of teaching and learning. These documents were drawn from various sources, including the Teaching and Learning International Survey (TALIS) reports (Organisation for Economic Co-operation and Development [OECD], 2009, 2014, 2019), TALIS country notes, OECD education policy outlooks (OECD, 2018), as well as national and international reports (Appendix 0).

Document analysis, as a specific analytical method, is essential in its ability to unveil patterns, themes, and insights within the selected documents. The documents examined were reviewed for relevance and recency, with a focus on materials released between 2000 and 2023 to ensure a contemporary and comprehensive examination of recent innovations and interventions in education. The document analysis process included a thorough examination of the contents, titles, and subtitles of these materials to identify critical information related to effective teaching, teacher professionalism, and the professional development (PD) of teachers in high-performing countries.

The selected documents were analyzed thematically, focusing on identifying recurring themes, patterns, and insights concerning effective teaching, teacher professionalism, and teacher development policies. The thematic approach to document analysis provides a systematic and comprehensive understanding of how each of the four countries addressed these vital aspects of education, aligning with the study's theoretical framework and emphasizing the Teacher Quality Framework, as well as relevant models such as Kind and Chan's (2019) PCK model.

3.4 Thematic Analysis

In order to examine teacher professional development (PD) in various educational environments in the Turkey, South Korea, Israel, and England nations, this study relies heavily on the approach of thematic analysis. The capacity of the qualitative research approach known as thematic analysis to methodically find, examine, and report on patterns and themes within the gathered data led to its selection. This approach is especially well-suited for qualitative, multi-country comparative research designs that aim to explore the many intricacies of professional development for teachers and their impact on pedagogical practices (European Commission, 2015; Vaismoradi & Snelgrove, 2019).

Using a deductive approach, the thematic analysis method used here is based on the categories of teacher knowledge shown in the 'teacher quality framework' figure from the previous chapter. The use of the deductive method guarantees that the analysis maintains a close relationship with the theoretical foundations and research goals of the study. The 'teacher quality framework,' including content knowledge (CK), pedagogical knowledge (PK), Community of Practice (CoP), Professional Beliefs and Virtues (PB&V) and pedagogical beliefs, is a theoretical construct that provides a background against which the data is compared (Çelik, et al., 2018; Tekin, 2021). This theoretical framework serves as the basis for the data categorisation into predetermined themes, which allows the analysis to capture and examine the important elements of teacher knowledge as it appears in the many educational situations that are the subject of the investigation.

Consider an example from the analysis of a Turkey policy document that was obtained from the case study repository Vezne and Günbayi (2016) to demonstrate how this thematic analysis is used. A new programme to improve teacher professional development is described in this document. Consistent with the deductive method, the analysis places the content of the document under the heading "Policy-Driven PD Initiatives." The sub-themes pertaining to the alignment of these activities with the 'teacher quality framework' are then highlighted. In the context of the suggested professional development activities, for example, the study explores the document's references to enhancing teachers' CK, PK, and the reinforcement of pedagogical beliefs as crucial components of teacher knowledge.

Similar to this, when analysing a teacher's account of their professional development experiences in South Korea, thematic analysis goes so far as to group their insights into themes like "Impact of Centralised PD Programmes" or "Teacher Autonomy in PD Choices." The 'teacher quality framework,' which emphasises the crucial interaction between teacher autonomy and the planning of centralised professional development programmes in moulding teachers' CK, PK, and pedagogical practices, is closely associated with these themes.

To summarise, the deductive thematic analysis technique, which is firmly based on the "teacher quality framework," provides a strong means of analysing the gathered data while maintaining a tight relationship between the study and the fundamental structures of teacher knowledge. This methodological decision allows for a more in-depth examination of the materials, revealing their relevance to the selected theoretical framework and its consequences for teaching practices.

3.5 Country-Specific Document Analysis

The details of the document analysis for each of the four locations that are being examined—the England, Israel, South Korea and Turkey are covered in further detail in the section that follows. In order to shed light on the unique aspects of teacher professional development (PD) and how the papers under analysis contribute to the understanding of the various educational systems, a national perspective is taken.

3.5.1 England: A Comprehensive Analysis of Teacher Professional Development

In this comparative analysis of teacher professional development (PD) and its influence on pedagogical practices, the focus shifts to England, a country renowned for its diverse educational landscape. England's approach to teacher development and its impact on classroom practices provide a captivating and intricate subject of examination. The study carried out by Tatto (2021) stated that:

"England have implemented professional development programs for teachers, ranging from short-term workshops to long-term mentoring and coaching programs" (p. 7).

This section delves into the case study conducted in England, offering a comprehensive analysis of the documented materials, various PD strategies, and their alignment with the "teacher quality framework."

For the case study in England, a meticulous examination of a wide range of sources was carried out as part of the document analysis process. These sources encompassed educational reports, documents from governmental bodies, and academic publications (See Appendix 0). The objective of this document analysis was to unravel the complexities of teacher professional development in England, elucidating the policies and strategies governing the enhancement of teacher knowledge and the transformation of classroom practices.

The analysis commenced by delving into the extensive array of educational reports and documents from governmental bodies. England's approach to professional development for teachers is substantially influenced by these documents, which shape the direction and implementation of various programs. Documents such as those from the Department for Education and Ofsted provide critical insights into the overarching objectives and key priorities of teacher professional development in England (DfE, 2010, 2011, 2014, 2016, 2018, 2022). They outline the parameters, resource allocation, and expectations for professional development programs.

Moreover, an evaluation of academic publications and scholarly works was an integral part of the analysis. These publications synthesized research findings, practical experiences, and challenges related to various aspects of teacher professional development. They offered a comprehensive view of how professional development significantly impacts educators and their classrooms. Additionally, interviews and surveys conducted with educators contributed a qualitative dimension to the analysis, offering their perspectives on the value and effectiveness of professional development activities.

England boasts a diverse array of professional development (PD) strategies, showcasing its commitment to enhancing teacher knowledge and pedagogical practices. These strategies encompass a spectrum of approaches, ranging from online platforms that facilitate collaborative professional development to school-based mentorship programs. The variety of teacher development initiatives in England underscores the nation's dedication to continuously improving the quality of education and pedagogy (Simon, James, & Simon, 2021).

According to the study conducted by Stoll et al., (2012) mentioned that;

..effective professional learning is school focused, school based and school led, whilst also drawing in external expertise where appropriate. Great professional development incorporates into this mix professional learning experiences that are sustained and intensive, rather than brief and sporadic, and that are undertaken collaboratively. We hope this review

will help deepen efforts to stimulate and explore great professional development which leads to consistently great pedagogy (Stoll et al., 2012, p. 8).

The comprehensive analysis of England's teacher professional development landscape provides valuable insights into the intricate relationship between professional development policies, strategies, and their impact on teaching practices. This exploration contributes to the broader understanding of the complexities of teacher professional development within England's educational context.

3.5.1.1 Online Platforms for Collaborative PD

Online platforms are becoming a common element of professional development for teachers in the England in the digital era. These platforms function as gathering places for educators to participate in group projects, exchange ideas about teaching, and have access to a multitude of teaching materials (Simon, James, & Simon, 2021). They enable instructors to interact with and learn from colleagues throughout the country, regardless of geographic constraints. Professional development options are flexible and easily available via these virtual Communities of Practice (CoPs). They promote a culture of continual development among educators by facilitating the sharing of concepts, tools, and best practices.

3.5.1.2 School-Based Mentoring Initiatives

Effective tools for teacher professional development include school-based mentorship programmes. In these programmes, seasoned educators mentor their colleagues, assisting them in developing as professionals (DfE, 2018, 2022). Through mentoring connections, new teachers may benefit from the experience of their more seasoned colleagues in a friendly setting. Reflection, teamwork, and skill development are encouraged by the mentor-mentee interaction. Educators may benefit from customised supervision and feedback by engaging in school-based mentorship, which can lead to better teaching practices.

Examining how well professional development policies connect with the "teacher quality framework" was a crucial component of the document analysis process. This framework is an all-encompassing theoretical model that prioritises the development of teachers' pedagogical beliefs and knowledge domains, such as CK and PK (DfE, 2021; Simon, James, & Simon, 2021).

According to Chai et al (2013), the framework, improving these areas is crucial to changing classroom practices. In the England, educators and policymakers have worked to match professional development (PD) programmes to the framework's concepts because they understand how important it is to improve teachers' knowledge and pedagogical convictions in order to raise the quality of instruction (Stroll, et al., 2012).

The country's dedication to developing a pedagogical culture that prioritises reflective teaching practices, ongoing development, and cooperation among educators is shown by its alignment with the 'teacher quality framework'. It emphasises how crucial it is to provide teachers with the resources they need to flourish in their positions and improve the learning results for students.

The case study of the England shed light on the complex character of teacher professional development in that nation. The document analysis revealed a wide range of professional development (PD) strategies, from school-based mentorship programmes to online platforms that support collaborative PD. The nation's dedication to providing educators with a range of opportunities for professional development is reflected in these strategies (DfE, 2016). The fact that these strategies are in line with the "teacher quality framework" further highlights the need of improving teacher knowledge and pedagogical practices as key components of raising educational standards in the country (DfE, 2021). The results of this case study add to the knowledge of teacher development in the England and provide information that may influence national and global policy and practice.

3.5.2 Israel: Navigating Policy Contestations and Regional Disparities in Teacher Professional Development

The case study of Israel provides a comprehensive exploration of PD for teachers in an intricate educational landscape characterized by policy disputes and regional disparities (OECD 2018). This investigation in Israel delved into an extensive array of documents, encompassing state-level educational policies, program evaluations, and in-depth policy case studies. These materials collectively painted a complex picture of how different regions within Israel handle teacher professional development, often at odds with one another (Donitsa-Schmidt & Ramot, 2020). The Israeli case study unravelled the intricate interplay between local policy decisions and the educational context, shedding light on how these factors influenced the alignment of PD initiatives with the "teacher quality framework." This alignment, in turn, shaped teachers' pedagogical beliefs, CK, and PK, thereby impacting their classroom practices.

The document analysis for the Israeli case study commenced with a thorough examination of state-level educational policies (Appendix 0). Israel's various regions, each endowed with a degree of autonomy in defining educational goals and policies, are primarily responsible for overseeing education. This led to an in-depth scrutiny of the educational policies of different regions within Israel. The formulation and implementation of teacher professional development programs in each region were guided by these policies (Dori et al., 2023; Stein, 2020).

Program evaluations were an integral part of the analysis, alongside the policies. These evaluations shed light on the outcomes and effectiveness of various PD efforts implemented across different regions. They provided insights into the advantages and disadvantages of the programs and their tangible effects on educators' professional development.

Furthermore, the document analysis encompassed in-depth policy case studies, focusing on regions where notable policy disputes and regional differences were particularly pronounced. These case studies provided a deep understanding of the intricacies of teacher professional development policies in specific regions, elucidating the challenges, objectives, and strategies governing professional development in those areas (Pandey, 2019).

In the context of Israel, the document analysis unearthed a web of policy disputes and regional differences. It became evident that several Israeli regions had adopted diverse approaches to teacher professional development policies, creating distinct educational environments (Tal, Herscovitz, & Dori, 2021; Stein, 2020; Sinclair, 2013). The analysis revealed that policy contestations constitute a prominent theme in Israel's educational landscape. Different regions often navigated teacher professional development with contrasting perspectives (Tal, Herscovitz, & Dori, 2021). The debates and conflicts surrounding the direction of teacher development efforts, allocation of resources, and alignment of professional development with region-specific educational goals served as visible manifestations of these contestations (Dori et al., 2023). The balance between locally tailored, bottom-up PD methods and standardized, top-down approaches was a recurring theme in these policy disputes. While some regions favored decentralized, school-based systems, others leaned towards centralized and standardized PD strategies (Zuzovsky & Donitsa-Schmidt, 2004). These disputes underscored the diversity of, at times incongruent, beliefs that inform teacher professional development in Israel.

Additionally, the document analysis revealed that different regions in Israel adopted distinct approaches to professional development for teachers, influenced by their geographical disparities. Legislative decisions in each region, coupled with unique regional educational contexts, left a significant imprint on these variations (Azulay, 2010). Regional factors encompassed socioeconomic status, cultural influences, and local demographics, which, in turn, influenced the planning, prioritization, and implementation of PD programs. Educators' experiences and opportunities for professional development were directly influenced by these differences in PD approaches (Stein, 2020). For instance, teachers in regions favouring decentralized models enjoyed greater flexibility and autonomy in shaping their professional development paths, whereas educators in regions preferring centralized, standardized PD often had access to a uniform set of knowledge and skills.

The analysis of the documents honed in on how teacher professional development activities aligned with the "teacher quality framework," a comprehensive theoretical model that underscores the enhancement of teachers' pedagogical beliefs and knowledge domains, including content knowledge (CK) and pedagogical knowledge (PK) (Reingold, 2022). According to the framework, refining classroom practices necessitates strengthening these areas (Sinclair, 2013). Due to disparities in regional contexts and policy approaches, there was variance in the degree of alignment with this framework among different regions in Israel.

The alignment with the 'teacher quality framework' underscored the importance of developing teachers' CK, PK, and pedagogical beliefs as a means to enhance classroom practices. Consistency in knowledge and skill standards was often associated with alignment in regions favoring centralized, standardized approaches. Regions that championed teacher autonomy, on the other hand, placed a strong emphasis on alignment by allowing educators to select professional development activities tailored to their unique teaching contexts and needs (Azulay, 2010; Ben-David, Kimhi, 2017).

3.5.2.1 Impact on Teachers' CK, PK, and Pedagogical Beliefs

In the context of Israel, the implementation of policy varied across regions and had a direct impact on the pedagogical beliefs, pedagogical knowledge, and subject knowledge of teachers (Zohar, 2008). Regions that leaned towards top-down, standardized approaches often resulted in more consistent knowledge bases for educators by ensuring uniformity in certain knowledge areas (OECD, 2014, 2019; Tal, Herscovitz, & Dori, 2021). However, this strategy could sometimes limit the flexibility and adaptability of teacher development.

Conversely, in regions where teacher autonomy held significant value, educators had the freedom to select professional development opportunities that specifically addressed their unique needs, enhancing their CK and PK in areas most relevant to their teaching contexts (Mamlok-Naaman, 2018; Mamlok-Naaman, Katchevich & Hofstein, 2016; Masry-Herzallah & Stavissky, 2023). Nevertheless, this approach sometimes led to greater variation in educators' knowledge areas.

Furthermore, the alignment of professional development programs with the "teacher quality framework" had a direct impact on the development of educators' pedagogical beliefs (Zuvosky & Donitsa-Schmidt, 204). Policies that emphasized educational principles as integral components of the framework promoted a culture of reflective teaching practices and a commitment to ongoing development (Dori et al., 2023).

The Israeli case study underscored the crucial role of regional educational environments in influencing policy decisions, which, in turn, affected the design and outcomes of professional development programs (RAMA, 2017). Israel's various regions operated within distinct social, cultural, and historical contexts, and these factors largely determined the objectives and aims of PD programmes in each region (Sinclair, Solmsen, & Goldwater, 2013).

For example, Israel's dedication to adhering to national educational standards and its emphasis on uniform knowledge domains across regions influenced some regions' preference for centralization and standardization in professional development (OECD, 2016; Tal, Herscovitz, & Dori, 2021). Conversely, regions that prioritized local control philosophies and promoted educators' autonomy were reflected in their support for decentralized, school-based professional development (Dori et al., 2023; OECD, 2016).

The Israeli case study provided a comprehensive examination of the challenges associated with teacher professional development in a system characterized by policy disputes and regional disparities. The document analysis illuminated the intricate interplay between regional educational contexts and policy decisions, influencing the alignment of professional development programs with the "teacher quality framework" and, subsequently, impacting teachers' subject knowledge, pedagogical knowledge, and pedagogical beliefs (Tal, Herscovitz, & Dori, 2021; Masry-Herzallah & Stavissky, 2023; Dori et al., 2023). The insights from this case study contribute to our understanding of teacher development in Israel by underscoring the significance of considering regional variations when devising and implementing professional development programs. Other nations seeking to tailor their teacher development strategies to their unique contexts can draw valuable lessons from Israel's experiences.

3.5.3 South Korea: Master teacher approach and unique PD

South Korea's case study offers a unique perspective on teacher professional development (PD) through an in-depth analysis of different South Korean regions (Li, 1998). This comprehensive examination delves into global professional development practices and provides a deeper understanding of how various South Korean regions approach teacher development. The study encompasses an array of texts, including evaluations of professional development programs, comparative studies, and educational policy documents.

Analysing these materials sheds light on the multifaceted approaches to professional development across South Korean regions and their impact on teachers' knowledge and pedagogical convictions. The document analysis enables a comparative exploration of papers from different South Korean regions, revealing both commonalities and differences in professional development strategies and their effects on educators' practices (Lee et al., 2019).

The document analysis for the case of different South Korean regions provides a rare opportunity to examine teacher professional development from a global perspective. The materials incorporated in this analysis originate from diverse South Korean regions, showcasing the wide array of educational practices, policies, and systems across the country (Lee et al., 2019). These documents, including policy guidelines and regulations established by multiple South Korean regions to govern professional development for teachers, outline the goals, requirements, and priorities of professional development initiatives (KEDI, 2015, 2016, and 2017). Evaluations and assessments of professional development programs offer critical insights into the outcomes and effectiveness of various initiatives, providing a comprehensive understanding of their practical implications on teachers, students, and pedagogical practices (South Korean Commission, 2020). Comparative research delves into teacher professional development practices across regional boundaries, seeking to identify trends, patterns, and variations in PD strategies across South Korean regions.

The document analysis from various South Korean regions reveals the diversity of teacher professional development strategies employed throughout the country. Each South Korean region adopts a unique approach to teacher development influenced by its educational objectives, cultural context, and historical influences (Lucero & Ocampo Jr, 2019). While it is not feasible to delve into the specifics of each region's strategy, the document analysis uncovers recurring themes and distinctions. South Korean regions differ in their preference for decentralized or centralized participatory designs. In several regions, teacher development is shaped and standardized by regional or local authorities through centralized, top-down PD strategies (UNESCO, 2017). In contrast, some regions embrace decentralized, school-based strategies that prioritize local control over professional development choices and teacher autonomy (KEDI, 2015).

Many South Korean regions recognize the value of consistency in teacher professional development, emphasizing long-term, sustained professional development programs that foster ongoing collaboration among educators (Kim & Reichmuth, 2021). By establishing Communities of Practice (CoPs) and other collaborative frameworks, these programs aim to promote cooperative learning and a sense of community. In contrast, several regions opt for brief, intensive professional development programs designed to provide instructors with specialized knowledge or skills within a limited timeframe (Byun & Jeon, 2023).

3.5.3.1 Teacher Professional Development in South Korean

Teacher professional development efforts in different South Korean regions do not always align with the "teacher quality framework." While some regions exhibit looser alignment, others explicitly incorporate framework categories such as CK, PK, and pedagogical values into their PD policies (Kim & Reichmuth, 2021). The commitment to enhancing teacher knowledge domains and pedagogical beliefs as essential tools for improving classroom practices is evident in the alignment with the framework. However, the extent and nature of this alignment are determined by each region's goals and policies. Different South Korean regions yield varying effects from PD strategies on teacher CK, PK, and pedagogical beliefs (Lee et al., 2019).

More centralized, standardized approaches often lead to a more consistent body of knowledge among educators. Nevertheless, there are instances where this uniformity may limit adaptability and customization of teacher development (Jung, 2020). In contrast, regions that support decentralized, teacher-autonomous models grant educators the flexibility to choose professional development opportunities tailored to their specific needs, enhancing their CK and PK in areas most relevant to their teaching contexts (Lucero & Ocampo Jr, 2019). The development of pedagogical beliefs among educators in different South Korean regions is influenced by adherence to the "teacher quality framework." Policies that emphasize educational principles as integral to the framework promote a culture of reflective teaching practices and a commitment to ongoing development (Yun, 1997). However, the extent to which these policies influence pedagogical beliefs varies among regions.

The comparative analysis of teacher professional development practices across South Korean regions highlights both similarities and differences. Commonalities include a dedication to expanding teachers' knowledge domains and a commitment to pedagogical principles as means to enhance classroom practices. Moreover, several South Korean regions emphasize continuity and collaboration in professional development, emphasizing long-term, ongoing initiatives that foster cooperative learning. Differences manifest in the alignment with the "teacher quality framework," the impact of PD strategies on teachers' CK, PK, and pedagogical beliefs, and the balance between centralized and decentralized approaches (Byun & Jeon, 2023). These variations reflect the diverse regional factors that shape teacher professional development practices and the complexity of South Korean educational systems.

The case study of different South Korean regions offers a comprehensive understanding of teacher professional development across the country. The document analysis sheds light on the diversity of methods for professional development for teachers, their alignment with the "teacher quality framework," and their impact on teachers' knowledge domains and pedagogical beliefs. The comparative analysis uncovers commonalities and differences in PD practices across South Korean regions, contributing to our understanding of teacher professional development from a national perspective.

3.5.4 Turkey: Exploring Disparities in Teacher Professional Development

In the comparative analysis of teacher professional development (PD) and its impact on pedagogical practices, Turkey emerges as a captivating case study country due to its unique educational system and the significant regional disparities in its approach to education. The analysis for Turkey encompasses a wide array of documents, encompassing educational policies, regional professional development program designs, and document narratives (Yazici & Gunduz, 2011; Gunel & Tanriverdi, 2014). This section delves into the specifics of the Turkish case study, providing an in-depth analysis of the document examination, the diversities in PD methods across regions, and the influence of local educational settings on PD outcomes.

The initial step in the document analysis for the Turkish case study involved a comprehensive exploration of national and regional educational policies. Turkey's educational system is characterized by a blend of centralized and decentralized elements, granting significant autonomy to different regions in determining their educational policies and practices (Çelik et al., 2018; Yazici & Gunduz, 2011). Consequently, the analysis encompassed an examination of national policies, such as those set forth by the Ministry of National Education, as well as regional policies from various provinces, including Istanbul, Ankara, and Izmir (MoNE, 2017).

These policies serve as the guiding principles and standards for PD initiatives within their respective jurisdictions.

In addition to policies, the analysis entailed a thorough review of regional PD program designs. Each Turkish province has developed its distinct professional development programs, tailored to their individual goals, resources, and pedagogical priorities (Gunel & Tanriverdi, 2014; McKinsey, 2011). The analysis delved into the intricacies of these programs, shedding light on their intended objectives and the strategies employed to facilitate teacher development.

Furthermore, the document analysis featured testimonies and narratives from Turkish educators across different regions. These first-hand accounts offered invaluable insights into the practical experiences, challenges, and benefits of professional development programs from the perspective of teachers. These qualitative elements enriched the analysis by providing a nuanced understanding of how professional development efforts influence the development of educators and their teaching practices.

A central finding of the document analysis was the significant disparities in teacher professional development among Turkish regions. The documents revealed varying approaches to teacher professional development, highlighting the diverse strategies employed in different provinces (MoNE, 2017). While some regions prioritize teacher autonomy in selecting professional development courses, others place a strong emphasis on centralized, standardized programs.

In several Turkish provinces, including Istanbul, centralized and standardized professional development (PD) programs take precedence in teacher development initiatives. These programs emphasize uniformity and consistency in professional development experiences, often closely aligned with regional curriculum and pedagogical objectives (Gunel & Tanriverdi, 2014). Educators in these regions participate in professional development programs structured and coordinated by provincial authorities, ensuring the acquisition of a common set of competencies and knowledge deemed essential for effective instruction.

In 2017, for continuous development of teachers, the MoNE launched its Teacher Strategy Paper 2017-2023, which aims to improve quality in teacher education. This initiative focused on achieving three main objectives; these are:

"Ensuring the employment of highly-qualified and well-trained teachers, who are most suitable for the teaching profession; ensuring continuous personal and PD of teachers; ensuring a positive perception towards the teaching profession and strengthening the status of the profession" (MoNE, 2017, p. 2).

Despite innovations and initiatives, the education system in Turkey has not generated highly qualified teachers who can support students' academic achievement. Research and the professional literature suggest that the quality of PD activities in Turkey tends to be less effective than PD offered in higher-performing countries (Gunel & Tanriverdi, 2014; Yazici & Gunduz, 2011). Atasoy and Cemaloğlu (2018) associated less effective PD with strongly centralised and top-down approaches. A strong centralised approach to education seems to confine teachers and educators' ability to generate high-quality instruction and to attend PD (Altinyelken, Çayır, Agirdag, 2015).

The comprehensive analysis of Turkey's teacher professional development landscape offers profound insights into the complexities of regional disparities in professional development approaches and their influence on pedagogical practices. This exploration contributes to a deeper understanding of the intricate relationship between regional policies, strategies, and their impact on teacher development and classroom practices in Turkey.

3.5.4.1 The Interplay Between PD Policies and Consequences

Areas that place a high value on teacher autonomy provide educators the liberty to explore professional development alternatives that are directly related to their own objectives and requirements. A highly individualised approach to teacher development is made possible by this autonomy, which also promotes a feeling of ownership and self-directed development. The elements of CK and PK that are most relevant to their particular teaching settings may be explored by educators (Yazici & Gunduz, 2011). Greater variation in the knowledge domains among educators might be one of the effects, however, and this could make standardisation more difficult.

3.5.4.2 The Role of Regional Educational Contexts

The case study of Turkey underscores the significance of local educational contexts in shaping the objectives and design of professional development programs. Turkey's provinces, each influenced by distinct social, cultural, and historical factors, embody unique educational landscapes. The goals and orientations of professional development programs are profoundly shaped by the regional context in which they operate.

For instance, the province of Istanbul, Turkey's economic and cultural hub, demonstrates a commitment to aligning teacher development with the regional curriculum and pedagogical requirements (Bai et al, 2020). This alignment is achieved through the emphasis on centralized and standardized professional development initiatives. Istanbul's educational authorities believe that fostering uniformity in educational practices is pivotal, and this belief serves as the cornerstone of their approach.

In contrast, provinces like Izmir place a strong emphasis on teacher autonomy in professional development pathways, reflecting the region's dedication to a more decentralized strategy (Frangenheim et al, 2020). Educators in Izmir are granted the freedom to choose their own professional development routes, a strategy that resonates with the local philosophy of individualization and regional autonomy.

In conclusion, the Turkish case study offers valuable insights into the diverse professional development practices for teachers across provinces. Through document analysis, it becomes evident that different regions in Turkey have adopted varying policies and strategies, with some prioritizing teacher autonomy in professional development choices, while others focus on centralized, standardized approaches (Gunel & Tanriverdi, 2014; MoNE, 2017). Furthermore, the study underscores the profound influence of regional educational contexts on the outcomes of professional development efforts. These insights contribute to a deeper understanding of teacher development in Turkey and underscore the importance of tailoring professional development strategies to the specific regional settings (Valverde-Berrocoso et al, 2021). The lessons gleaned from this case study are not limited to Turkey alone; they hold relevance for other nations seeking to customize their teacher development approaches in accordance with their unique regional circumstances.

3.6 Comparative Analysis of Case Studies: Teacher Professional Development in the England, Israel, South Korea and Turkey

Across the globe, educational systems rely heavily on teacher professional development (PD) to enhance teachers' pedagogical beliefs, pedagogical knowledge, and content knowledge (CK, PK), which in turn influences their pedagogical practices (Pettersson, 2021). This comparative analysis looks at case studies from the England, Israel, South Korea and Turkey to acquire a better understanding of PD practices. The aim is to ascertain the shared themes and differences in these areas' methods to professional development for teachers and its impact on their pedagogical practices and knowledge.

The comparative analysis reveals a similar theme: the understanding of the crucial role that teacher knowledge plays in forming successful instructional practices. Every area agrees that improving CK, PK, and pedagogical beliefs is necessary for instruction to be successful (McCallum & Coombe, 2020). This acknowledgement is part of a global trend that places emphasis on the professional development of teachers and how it directly affects the learning results of students.

Recognising the importance of knowledge sharing and collaborative learning among educators is another prevalent topic. Communities of Practice (CoPs) are emphasised as a key tool for facilitating this kind of cooperation (Wenger, 1998). Unlike short-term, non-collaborative techniques, CoPs provide instructors with a venue to gather, exchange knowledge, and participate in ongoing collaborative learning. This is considered a powerful type of professional development.

Additionally, all regions agree that one of the most important ways to improve teacher practices is to support teachers' CK, PK, and pedagogical beliefs. The emphasis on the global commitment to increasing teacher quality is highlighted by this connection with the theoretical framework of the 'teacher quality framework' (Guskey, 2002).

3.6.1 Disparities and Policy Implications

Even with these similarities, there are also clear differences across the areas, especially when it comes to how well PD programmes fit into a larger theoretical framework. Policy consistency and fair access are challenged by the varied character of professional development (PD) programmes in the England, which include online platforms, school-based mentorship, and digital communities (Jiang et al, 2021). This discrepancy emphasises the need for a more uniform and just approach to PD nationwide.

Turkey provinces differ greatly from one another; some support centralised, standardised professional development programmes, while others place a higher value on teacher autonomy in selecting their own professional development paths (Chen et al, 2020). Although each strategy has advantages, the disparity highlights how difficult it is to strike a balance in PD between consistency and flexibility. Turkey struggles with regional differences and policy contestations, highlighting the importance of local circumstances in influencing PD results (MoNE, 2017). This variation in policy approaches throughout the nation highlights how crucial it is to take particular local settings into account when creating successful professional development initiatives.

Comparative analysis indicates different techniques that represent different educational philosophies and systems in the instance of South Korea. A frequent theme is the effect of local settings on how well professional development activities match with teacher knowledge and pedagogical practices (Li, 1998; Jung, 2020; Yun, 1997). This emphasises how crucial it is to take into account the particular local context while creating and executing successful PD.

3.6.2 Community of Practice (CoP)

Another aspect that varies across the countries is the presence and use of CoP as a collaborative learning strategy. The case study for England demonstrates the development of online communities for educators that may serve as CoP. These platforms enable teacher collaboration, knowledge sharing, and ongoing learning. Moreover, England places significant emphasis on fostering professional collaboration among teachers, as evidenced by the Department for Education's (DfE) report (2014) which underscores the importance of good working relationships among teachers. According to the report,

"Good working relationships between teachers in England, such as better cooperation and collaboration, are strongly associated with teachers' self efficacy" (DfE, 2014, p. 173).

Further, report added that, *"there is also a positive, and statistically significant, association between the professional collaboration index and teacher self-efficacy"(DfE, 2014, p.185) and concluded that "it should be noted that the indices of exchange/coordination for teaching, professional collaboration, and teacher cooperation are very strongly correlated with each other"* (DfE, 2014, p.186).

This perspective aligns with the broader global movement promoting collaborative learning within the educational community, underlining the value of Communities of Practice (CoPs) as a significant avenue for professional development and the enhancement of teaching efficacy.

In Turkey, where there is an emphasis on teacher autonomy in professional development choices, instructors participating in similar professional development programs may spontaneously form unofficial CoP, as

MoNE (2017) mentioned that "Many professional development activities are organized by the Ministry with the motto of 'qualified teachers and qualified education" (p.18).

The extent to which CoP emerge may depend on how well the balance between standardized professional development and teacher autonomy is maintained. However, regional differences and policy considerations in Israel may influence the formation and use of CoPs. Varying policies and practices in different regions may impact the extent of collaborative learning that teachers can engage in.

In the case of South Korea, the presence and adoption of CoP as a PD strategy may differ depending on the specific regions. The local educational context and each region's emphasis on collaborative learning can influence the existence and effectiveness of CoP.

3.6.3 Pedagogical Content Knowledge (PCK)

Both topic knowledge and pedagogy are usually balanced in England's teacher training and development programmes. The quality of teaching is highly valued by the Department for Education (DfE), and effective teacher training programmes are designed to produce educators with both subject-matter expertise and effective pedagogical techniques (Wang et al, 2019). DfE publications and documents frequently emphasise the value of topic knowledge, teaching techniques, and teacher expertise. As stated in a DfE report from 2010,

“The new National Curriculum will therefore have a greater focus on subject content, outlining the essential knowledge and understanding that pupils should be expected to have to enable them to take their place as educated members of society.” (DfE, 2010, p. 42)

This highlights the emphasis on subject content as an essential component of effective education. Additionally, England encourages the use of effective teaching strategies, as articulated in a more recent DfE document from 2021. It states that;

“Appropriate self-evaluation, reflection and professional development activity is critical to improving teachers’ practice at all career stages. The standards set out clearly the key areas in which a teacher should be able to assess his or her own practice, and receive feedback from colleagues. As their careers progress, teachers will be expected to extend the depth and breadth of knowledge, skill and understanding that they demonstrate in meeting the standards, as is judged to be appropriate to the role they are fulfilling and the context in which they are working.” (DfE, 2021, p. 7).

Furthermore, a DfE publication from 2022 highlights the commitment to evidence-based training and professional development;

“Every teacher and school leader now has access to a golden thread of high-quality, evidence-based training and professional development at every stage of their career. By providing training on areas that are fundamental to high-quality teaching like behaviour management, adaptive teaching and curriculum design, these reforms will help teachers and leaders to support all pupils to succeed, including those identified with special educational needs and disabilities (SEND)” (DfE, 2022, p. 17).

The DfE's vision, as outlined in 2022, underscores the commitment to delivering a broad and knowledge-rich curriculum to all children, ensuring high-quality education from the early years onwards, and providing access to enriching extra-curricular activities (DfE, 2022).

"From early years onwards, all children will be taught a broad, ambitious, knowledge rich curriculum and have access to high-quality extra-curricular provision" (DfE, 2022, p. 24).

This holistic approach to teacher training and education seeks to produce well-rounded educators who are equipped with both deep subject knowledge and effective pedagogical skills to provide high-quality instruction.

Meanwhile, Israel has taken significant strides in elevating the quality of teaching through a series of comprehensive educational reforms and policy initiatives. Israel's approach to Pedagogical Content Knowledge (PCK) is undoubtedly influenced by reformative measures. The central objective is to equip educators with the requisite skills to effectively convey content knowledge to their students. .

As evidenced in scholarly sources, the curricular emphasis in contemporary Israel is notably directed towards themes encompassing

"…evolution and sustaining peoplehood, state seeking, state making, and eventually state keeping" (Stein, 2020, p. 92).

Moreover, the curriculum incorporates "morally complex narratives and texts in Israeli society" (Reingold, 2022, p. 53). Furthermore, the scholarly discourse underscores the need for educators to transcend being proficient Jewish educators who merely possess knowledge of or have visited Israel. Instead, an imperative has arisen to cultivate approaches that seamlessly synthesize specific pedagogical strategies with Israel-related content.

"Israel educators will not succeed by being good Jewish educators who also happen to know about, or have visited Israel. Rather, approaches must be developed that synthesize specific pedagogical approaches with Israel-related content" (Sinclair, 2013, p. 2)

In the domain of teacher training, Israel's educational institutions adhere to a concurrent model, which ingeniously amalgamates disciplinary and pedagogical contents, fostering a well-rounded and effective teacher training approach (Zuzovsky & Donitsa-Schmidt, 2004).

"Teacher training in these colleges follow the concurrent model which combines disciplinary and pedagogical contents" (Zuzovsky & Donitsa-Schmidt, 2004, p. 52).

Lastly, an alternate perspective emphasizes the transformative nature of experience, positing that with augmented knowledge and practice, teachers' professional identities are continuously reshaped over time (Hilel & Ramírez-García, 2022).

“Another view stresses that experience, with increased knowledge and practice, reshapes teachers’ professional identity over time” (Hilel & Ramírez-García, 2022, p.2).

This affirms Israel's commitment to nurturing a cadre of educators who evolve in their professional capacities through a dynamic interplay of experience and knowledge.

The stringent methods underpinning South Korea's teacher development program are widely acknowledged. The integration of Pedagogical Content Knowledge (PCK) within teacher training programs is presumed to be meticulously delineated in policy reports and other authoritative documents obtainable from the Korean Educational Development Institute (KEDI). “Korea is able to recruit and retain teachers with professional knowledge and teaching skills” (KEDI, 2015, p.32). It is evident that South Korea's unwavering commitment to providing high-quality education is intricately interwoven with the application of PCK in its teacher development initiatives (Li, 1998; Jung, 2020; Yun, 1997). These initiatives are primarily directed towards the enhancement of teaching competencies and the advancement of pedagogical knowledge. As affirmed by UNESCO (2017),

“Moreover, along with the idea that the new education system should be moved from knowledge based learning to competency based learning, the six key competencies were defined as the core skills for Korean students in the new curriculum. These include “self-management,” “knowledge and information processing,” “creative thinking,” “aesthetic sensibility,” “communication skills,” and “civic competency.” These key competencies act as fundamental guidelines for the teachers in both teaching and student assessments.” (UNESCO, 2017, p. 12)

The goal of Turkey's Ministry of National Education (MoNE) is to advance professional development and teacher quality. Although exact quotations are not given, it is likely that Turkey's approach includes some PCK components in teacher training programmes. Turkey has been working to enhance teacher quality and professional development initiatives, with a focus on a comprehensive strategy that incorporates pedagogical topic knowledge. MEB stated;

“Instead of determining a subject specific competency for each subject area, subject matter knowledge and pedagogical content knowledge have been added in the general competencies” (MoNE, 2017, p.13).

3.6.4 PB&Vs (Professional Beliefs and Virtues)

In shaping the values, ethics, and dedication of teachers, Professional Beliefs and Virtues (PB&V) in education are essential. Policy documents and educational practices show that different countries address PB&V in different ways. Policy documents such as ‘Teachers’ Standards guidance for school leaders, school staff and governing bodies’ (DfE, 2011) in England emphasized teacher professionalism and ethical standards. These standards provide a framework for professional beliefs and virtues, promoting self-evaluation, introspection, and professional virtues as essential elements of teacher practice (DfE, 2021). Through extensive training and development activities, ‘the Department for Education (DfE) is dedicated to improving teacher competency and fostering a professional attitude’ (DfE, 2018).

PB&V in education is approached in a way that is consistent with the ethical and cultural values of the country, which are frequently mirrored in educational procedures (Reingold, 2022). Sinclair, Solmsen and Goldwater (2013) pointed out that the goal of Israel is to produce educators who not only have the pedagogical know-how but also uphold the values and virtues that are essential to effective teaching. The qualities and competences of educators within the Israeli context are the subject of academic investigations like "The Israel educator: An inquiry into the preparation and capacities of effective Israel educators" (Sinclair et al., 2013).

The cultural values of South Korea, which priorities academic performance and discipline, have influenced the country's approach to PB&V in education (Li, 1998). South Korea's educational policies, as influenced by the Programme for International Student Assessment (PISA) (Kim & Choi, 2023), indicate the country's dedication to fostering an excellence in education culture.

In the "Teacher Strategy Document 2017-2023" (MoNE, 2017), the Ministry of National Education (MoNE) of Turkey has outlined a clear vision for teacher professionalism. The relevance of ongoing training and development is emphasised in this text by highlighting the evolution of teachers' professional identities. The moral and ethical aspects of teacher jobs are also highlighted in the general competences that Turkey has established for the teaching profession (MoNE, 2017; "Teachers' General Competencies" document).

The understanding of the crucial role that professional beliefs and virtues play in shaping the ethos of teaching and learning is the common thread that unites each of these countries' approaches to PB&V in education. To develop educators with the professional and moral virtues required for effective teaching and a strong dedication to education, policies, professional standards, and cultural values are combined.

3.6.5 Alignment with 'Teacher Quality Framework'

Alignment with a comprehensive theoretical framework, such as the 'teacher quality framework,' is another characteristic that differs throughout the areas. In Turkey, the multifaceted nature of PD programs poses challenges in terms of policy coherence and equitable access (Diem & Welton, 2020). This can lead to discrepancies in the alignment of PD initiatives with the framework. Meanwhile, in South Korea, the variations in PD approaches across regions may affect the degree to which PD programs align with the 'teacher quality framework'. The balance between standardized and autonomous PD may impact the extent to which PD programs reflect the framework's dimensions.

Israel's policy contestations and regional disparities create variations in the alignment of PD initiatives with the 'teacher quality framework'. Local contexts and policy choices influence the extent to which PD programs prioritize the enhancement of teacher knowledge and pedagogical practices.

In the English context, the alignment with the 'teacher quality framework' varies based on the policies and practices of individual regions. The existence of a comprehensive theoretical framework does not guarantee universal alignment in the absence of concerted efforts to harmonize policies.

3.6.6 Toward a Global Perspective

This comparative analysis reveals the complex and multifaceted nature of teacher PD in different regions. While there are common themes, such as the recognition of the importance of teacher knowledge and the value of CoPs, there are also significant disparities in policy approaches and alignment with theoretical frameworks.

The findings of this analysis emphasize the importance of adopting a global perspective when examining teacher PD. The diversity of approaches and the influence of local contexts underscore the need for international dialogue and knowledge sharing. Educators and policymakers can learn from each other's successes and challenges to improve teacher development on a global scale.

This comparative analysis provides valuable insights into the multifaceted landscape of teacher professional development in the England, Israel, South Korea and Turkey (Joynes et al, 2019). It highlights common themes, disparities, and policy implications, emphasizing the need for a global perspective in understanding and advancing teacher development. Through collaborative efforts and knowledge sharing, educators and policymakers can work together to enhance teacher knowledge and pedagogical practices worldwide.

Table 3. 1: Summary of Key Findings in Case Studies

Country	Key Findings
England	- Multifaceted nature of PD programs - Challenges in policy coherence and equitable access -Diversity of PD strategies, including online platforms and mentorship programs
Israel	- Policy contestations and regional disparities - Influence of local contexts on PD outcomes - Diverse policy approaches within the country
South Korea	- Diverse approaches reflecting varied educational philosophies and structures - Influence of local contexts on policy choices and alignment with theoretical frameworks
Turkey	- Variations between provinces in PD approaches - Struggle to balance centralized and autonomous PD - Potential for teacher autonomy in PD choices

3.7 Education System of England

The compulsory education system in England is divided into 'key stages' premised on age. The Early Years Foundation Stage is for 3-5-year-olds; Key Stage 1 (children aged 5-7) and Key Stage2 (children aged 7-11), cover primary education, with Key Stages 3 (children aged 11-14) and 4 (children aged 14-16) comprising secondary education. Students are expected to stay in education or training, that is, post-16 education up to the age of 18 (EP-Nuffic, 2015). All 16-year-olds sit General Certificate of Secondary Education (GCSE) exams in the core subjects of English, mathematics and science, and optional subjects based on students' preferences. Students choosing to stay in school take between two and four A levels in selected subjects at the age of 18. A level results are used to determine entrance to university. The English education system depends upon the award of achievement in external examinations, along with a degree of student choice (European Parliament, 2014).

3.7.1 England's Performance in International Assessment Tests

In 2015 England's students scored significantly higher the OECD average of 493 in PISA. The 2015 PISA data shows England ranked fifteenth in science among 70 countries (Jerrim & Shure, 2016). There is a trend towards a decrease in average score of 14 points between 2006 and 2018.

As Figure 3.7 shows, the performance of England's students (aged 13-14) in TIMSS in science, has been significantly above the international mean score of 500 (Greany, Barnes, Mostafa, Pensieron, & Swensson, 2016). In TIMSS 2015, England ranked fifteenth among 47 countries for year 5 (children aged 9-10) students' science and eighth among 39 countries for year 9 (children aged 13-14) pupils' science scores (Greany et al., 2016).

England's performance in TIMSS over the last 10 years has change negatively. Pupils' TIMSS scores for England follow a similar pattern to the PISA scores. There is a trend towards with a decrease in average score of 27 points between 2007 and 2019. International assessments for England revealed a drop in student scores between 2015 and 2019. England is the only one among the four case study nations whose TIMSS ranking has fallen (from 8 to 14).

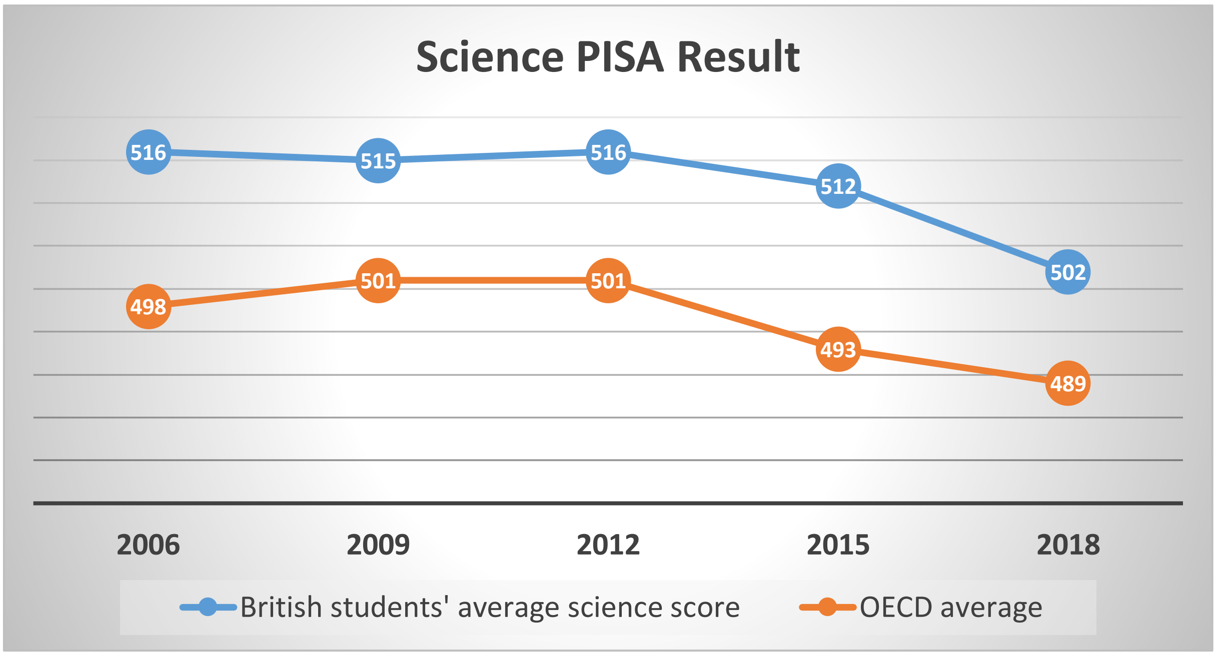


Figure 3. 1: Average science scores of English students in PISA tests between 2006 and 2018 (Adapted from Bradshaw et al. (2007); Wheater et al. (2013); PISA 2015 database; OECD, 2018)

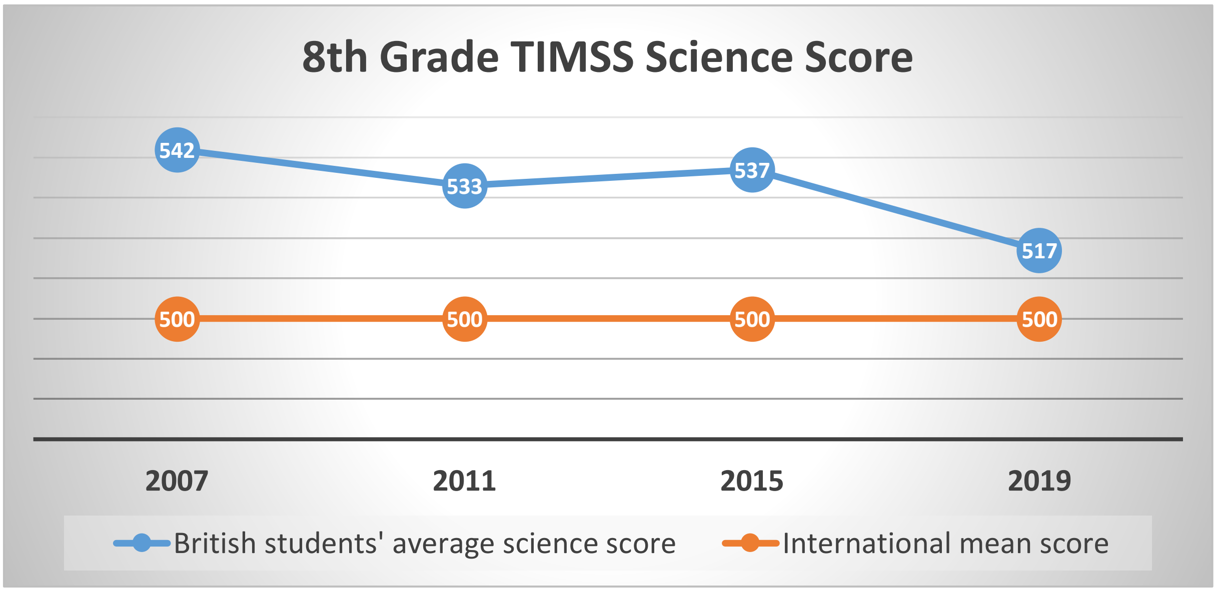


Figure 3. 2: Year 9 - Aged 13-14 English students' TIMSS science scores between 2007 and 2019 (Adopted from TIMSS, 2015; TIMSS, 2019)

The data shows some fascinating patterns in England's results in international tests. Ranking fifteenth out of 70 nations in the 2015 PISA results, English students beat the OECD average in science. The decline in scores between 2006 and 2018 was, nevertheless, a worrying trend, with a 14-point increase. Ranking fifteenth for Year 5 students and eighth for Year 9 students in 2015, England's students regularly outperformed the international mean in TIMSS. TIMSS scores did, however, significantly decline over the previous ten years, following the PISA pattern. This decline is distinct because, in contrast to the other case study countries, England's TIMSS ranking dropped from eighth to fourteenth.

3.7.2 Teacher Education in England

Initial teacher education programmes in England (Foster, 2019) are designed to meet teachers' standards (DfE, 2011); these define the minimum level of practice expected of teachers from the point of being awarded qualified teacher status (QTS). QTS is awarded by the Teaching Regulations Agency (TRA) (Eurydice — European Commission, 2018). Routes to becoming a qualified teacher vary and include "school-centred" training such as the Schools Direct, School-Centred Initial Teacher Training (SCITT) programmes and Teach First. ITT may be 'higher education-centred' comprising a 1-year, university-based postgraduate certificate in education (PGCE) after completion of an undergraduate degree, or, for primary education only, a specific undergraduate degree that provides QTS.

3.8. Education system in Israel

Israeli education comprises primary and secondary education. Primary education is divided into two stages. Children aged 3-6 attend compulsory kindergarten followed by 6 years of primary school. Secondary education is divided into 3 years of lower secondary for 12-15-year-olds and 3 years of upper secondary school for 15-18-year-olds. In upper secondary school, two pathways known as the 'general' and 'technology' tracks allow students to select their preferred additional courses in addition to the core curriculum (Azulay, Ashkenazi, Gabrielov, Levi-Mazloum, & Dov, 2013). After grade 12 (18 years of age), students take the Bagrut examination for university entrance. Students attend one of four types of school: secular, orthodox, Arab, or independent. Independent schools are attended by children from ultra-Orthodox (Haredi) Jewish families and allocate little time to secular education (OECD, 2016).

3.8.1 Israel's performance in international assessment tests

Israel's education system is rapidly improving, as evidenced by its PISA science and mathematics scores between 2006 and 2018. The 'New Horizon' reform played a significant role in this rapid improvement (Reingewertz & Shany, 2016). Figure 3.3 shows that Israeli students have improved their mean science and mathematics scores, gaining approximately 13 points in science and 28 points in mathematics (Ben-David & Kimhi, 2017). In TIMSS, as Figure 3.4 shows, the average achievement score for Israeli students is higher than the international average scores for students in the 39 participating countries (The National Authority for Measurement and Evaluation in Education (RAMA), 2017).

Students' TIMSS scores in Israel follow a pattern comparable to PISA scores. Between 2006 and 2012, there is an increase in average score of 16 points in PISA and 48 points (significant increase) in TIMSS. The following period between 2012 and 2019 shows a trend with a constant decrease in PISA. During this time period, there was a fluctuation in students' test scores. The TIMSS score decreased in 2015 and increased again in 2019. But there was a dramatic increase of 45 points overall between 2007 and 2019.

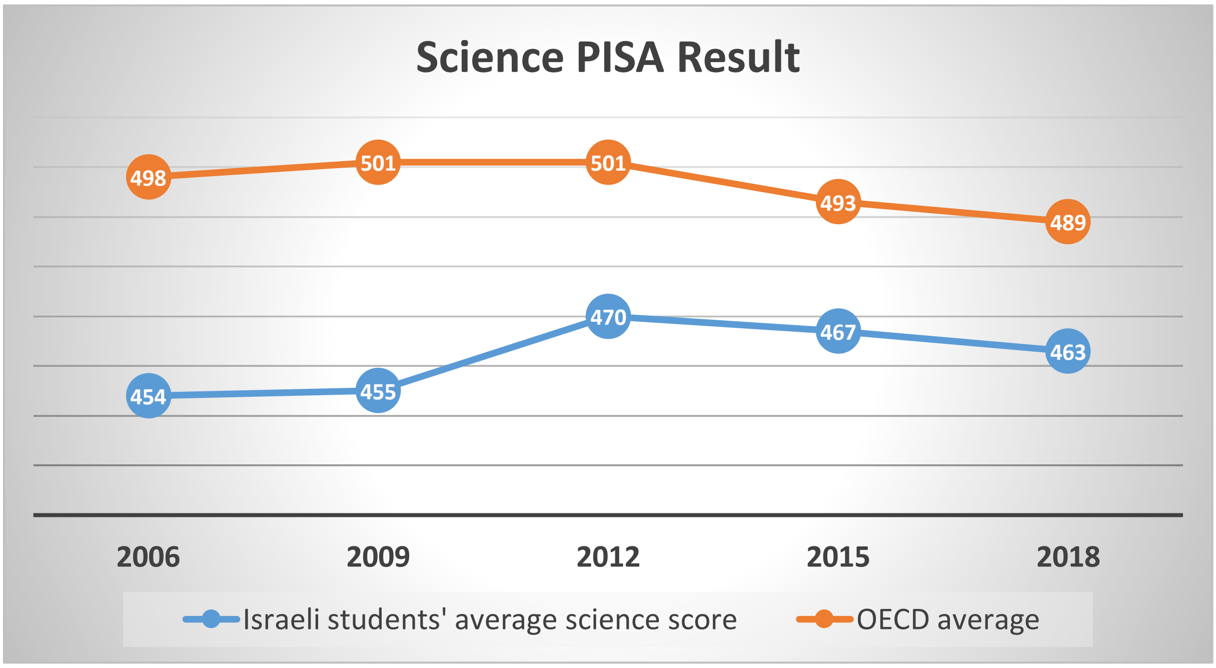


Figure 3. 3: Average science scores of Israeli students in PISA tests between 2006 and 2018 (Adapted from Ben-David & Kimhi, 2017; OECD, 2018)

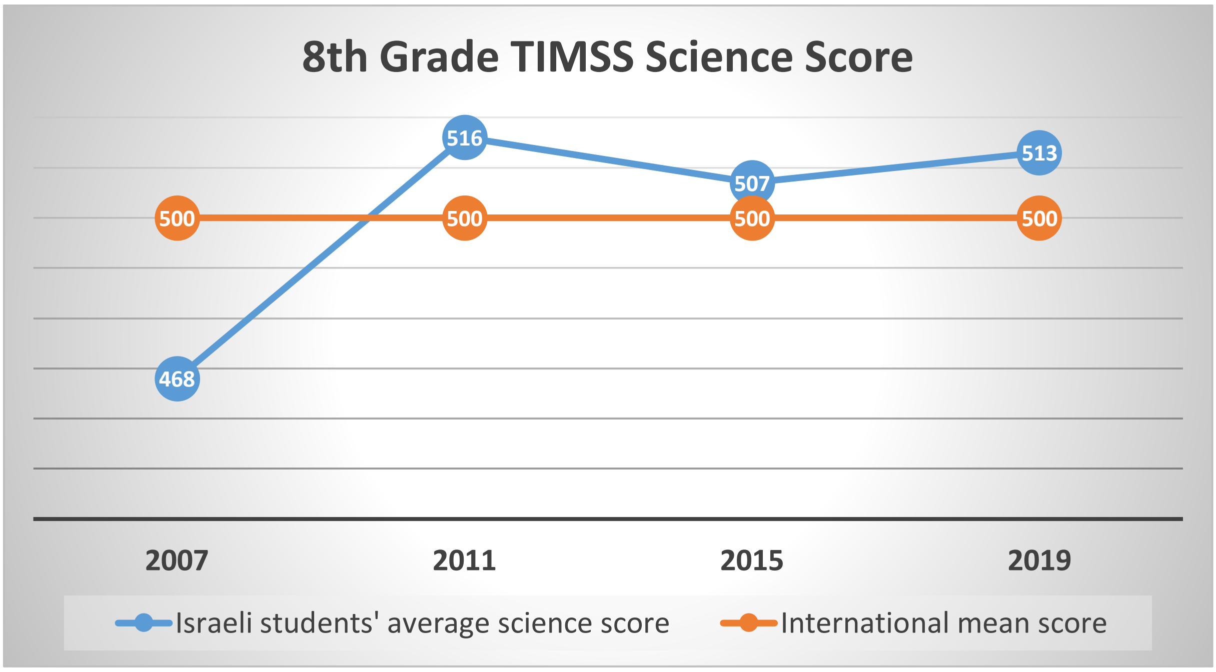


Figure 3. 4: 8th grade Israeli students' TIMSS science scores between 2007 and 2019 (Adapted from TIMSS, 2015; TIMSS, 2019).

3.8.2 Teacher education in Israel

Initial teacher education takes place in colleges and in schools of education at universities. A new policy was introduced in 2003 (Azulay, 2010). This requires teachers to complete their first year of teaching as an 'induction' year before obtaining a teaching licence (Zuzovsky & Donitsa-Schmidt, 2004). Prerequisites for obtaining an education licence include a teaching certificate, an academic degree, and successful completion of induction. From 2006 onwards, the pedagogical component of teacher education programmes was extended from 24 to 30 hours annually and comprises educational studies, research methodology, and pedagogical studies, including a supervised placement. Overall, the pedagogical component complements 60 hours per year of disciplinary studies.

3.9. Education System in South Korea

The education system in South Korea comprises three tiers, namely primary (Grade 1-6; aged 7-12), middle (Grade 7-9; aged 13-15), and high schools (Grade 10-12; aged 16-18). Attendance at primary and middle schools is compulsory (Korean Educational Development

Institute, 2015). Four types of high schools, namely general, special-purposed, vocational, and autonomous schools are available. Places at prestigious high schools are competitive and students take a transition examination to determine which school they will attend. High school students choose either liberal arts, that is, humanities and social science, or natural sciences. Students take the College Scholastic Aptitude Test (CSAT) to determine university entrance (KEDI, 2017).

3.9.1 South Korean's performance in international assessment tests

As stated by Korean Educational Development Institute (KEDI), "Korea is one of the top performing OECD countries in Programme for International Student Assessment (PISA)." (KEDI, 2015, p.6). Notwithstanding the recent decline in PISA scores, Korean students consistently exhibit superior academic proficiency in all subjects when compared to the OECD average. In 2015 and 2018, The trend for South Korea shows decline in PISA scores. The trend for South Korea shows that Korean students' average science score is much higher than OECD average (Figures 3.5 and 3.6). In TIMSS, students are ranked in the top three each test.

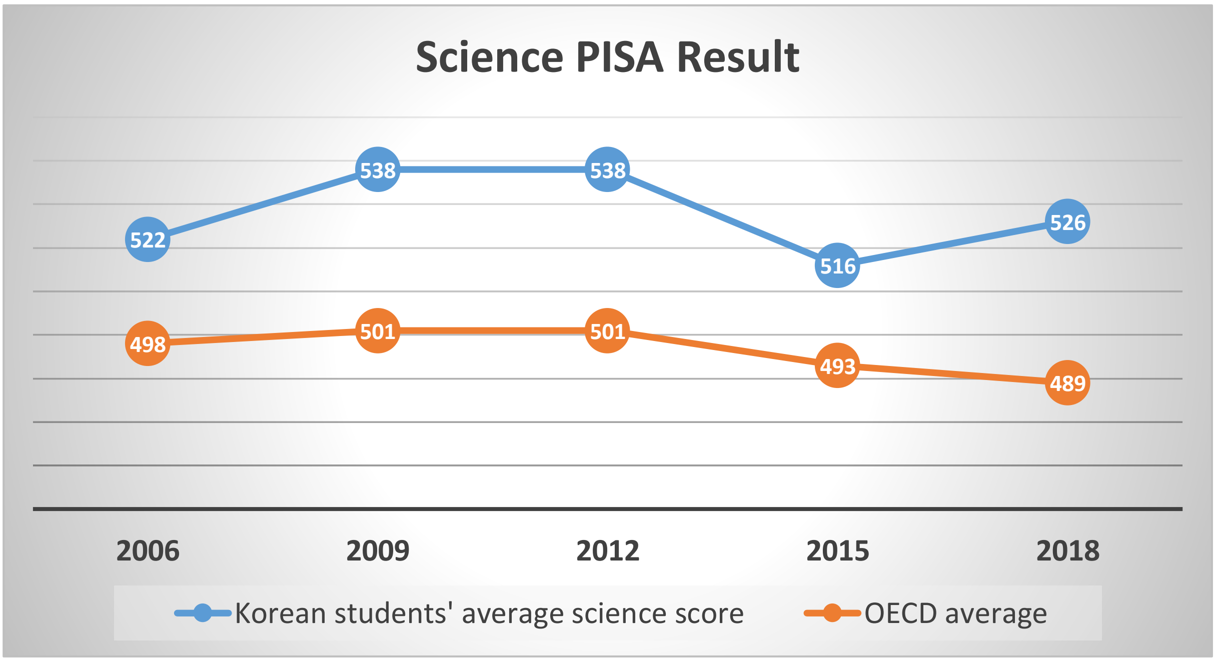


Figure 3. 5: Average science scores of Korean students in PISA tests between 2006 and 2018 (Adapted from PISA 2015 Results in Focus. Report for Korea. KEDI; OECD, 2018)

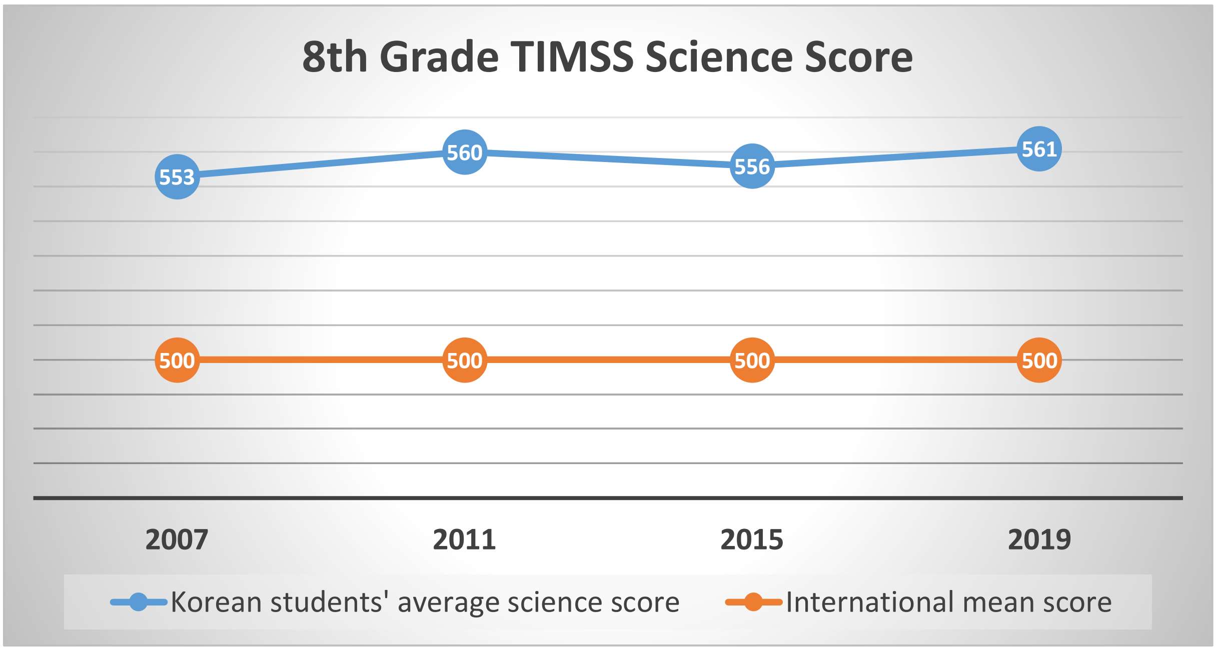


Figure 3. 6: 8th grade Korean students' TIMSS science scores between 2007 and 2019 (Adapted from TIMSS, 2015; TIMSS, 2019)

3.9.2 Teacher Education in South Korea

Three routes lead into science Initial Teacher Training programmes, namely teacher education institutes, general universities, and graduate schools of education (Jho, Song, & Hong, 2016). Teacher education institutes comprise three types with each offering teacher certification to all graduates. Twelve universities of education train only elementary school teachers; colleges of education are divisions of public and private universities that provide training only for secondary school teachers; and the Korean National University of Education (KNUE) trains teachers for kindergarten, primary, and secondary teaching (Park, 2014). General universities produce some teachers via studying courses in pedagogy offered by the school's college of education. Graduate schools of education specialise in PD of in-service teachers (Park, Byun, Sim, Han, & Baek, 2016). Some teachers train in these schools after earning an undergraduate degree. Such teachers take courses in pedagogy and receive a teaching certificate when they graduate (Im, Yoon, & Cha, 2016). Students who graduate in any of these pathways need to take a National Teacher Evaluation Test (NTET) to apply for a teaching position. After 3 years, teachers can acquire a Grade 1 Teaching Certificate through attending PD courses

3.10 Education System in Turkey

The Turkish education system, known as '4+4+4', was adopted on March 30th, 2012 (Milli Eğitim Bakanlığı, 2012). The 4+4+4 system increased the period of compulsory education, extending mandatory schooling to 12 years, comprising 4 years in primary school, 4 years in middle school (lower secondary), and 4 years in high school (upper secondary) (Gün & Başkan, 2014). To gain admission to higher education (HE) in Turkey, students sit a two-stage standardised national test: the Yükseköğretim Kurumları Sınavı (YKS I) Transition to Higher Education Examination which comprises core subjects such as Turkish, basic mathematics, and social and natural sciences. The YKS II comprises mathematics, natural sciences, literature and geography, social sciences, and a foreign language. Students submit their secondary school achievement score (European Parliament, 2014). The new education system aimed to direct students to particular tracks based on their academic qualification in the early stage and to improve vocational education (Odabasi, 2014).

3.10.1 Turkey's performance in International Assessment Tests

Figure 3.7 shows the average scores of Turkish students in science, mathematics, and reading in PISA tests between 2006 and 2018. Although a steady increase is observed in all subjects, Turkey's scores are below the OECD average (Bakir, Demirel, & Yilmaz, 2015). In PISA 2015, Turkey ranked fifty-second in science among 70 countries, fiftieth in reading and forty-ninth in mathematics (Çelik et al., 2018). TIMSS data tells the same story: average scores for grades 4 and 8 in mathematics and science tests remained below the TIMSS scale median (see Figure 3.8) and Turkey ranked thirty-sixth out of 49 countries in grade 4 mathematics scores and thirty-fifth out of 47 countries in science. At grade 8, Turkish students ranked twenty-fourth out of 39 countries in mathematics and twenty-first out of 39 countries in science (Çelik et al., 2018).

The trends in Turkey's TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) results between 2006 and 2019 reveal noteworthy developments. During this period, Turkey demonstrated the most substantial increase in average TIMSS scores among the four case study nations, showing a remarkable rise of 83 points. Such a significant improvement in TIMSS scores signifies the country's dedication to enhancing its students' performance in curricular knowledge in mathematics and science.

In contrast, the increase in PISA scores in Turkey was more modest, with an average rise of 30 points. This discrepancy in the rate of increase between TIMSS and PISA scores can be attributed to the varying focuses of these assessments. As mentioned earlier study, TIMSS primarily measures students' curricular knowledge, assessing their proficiency in subjects according to established curricula. PISA, on the other hand, centers on evaluating students' intellectual virtues, which encompass critical thinking, analytical thinking, and decision-making skills.

The explanation for the difference in Turkey's PISA and TIMSS scores lies in the nature of the tests. In essence, the higher increase in TIMSS scores could be influenced by Turkey's commitment to strengthening its students' knowledge of the curriculum in mathematics and science. However, the more moderate increase in PISA scores suggests that the development of students' intellectual virtues and higher-order thinking skills, as measured by PISA, may have faced different challenges or priorities during the same period.

Furthermore, it's essential to note that the relatively lower increase in PISA scores doesn't necessarily indicate a lack of progress. It might be challenging to significantly increase already high PISA scores, as PISA tends to assess skills that are more reflective of overall cognitive abilities, which may have already been relatively strong in the Turkish student population.

The difference in Turkey's PISA and TIMSS scores can be explained by the differing focuses of these assessments, with TIMSS emphasizing curricular knowledge and PISA focusing on higher-order cognitive skills. The substantial increase in TIMSS scores reflects Turkey's dedication to enhancing curriculum-based knowledge, while the more modest increase in PISA scores may be attributed to the challenge of further improving already strong cognitive abilities as measured by PISA.

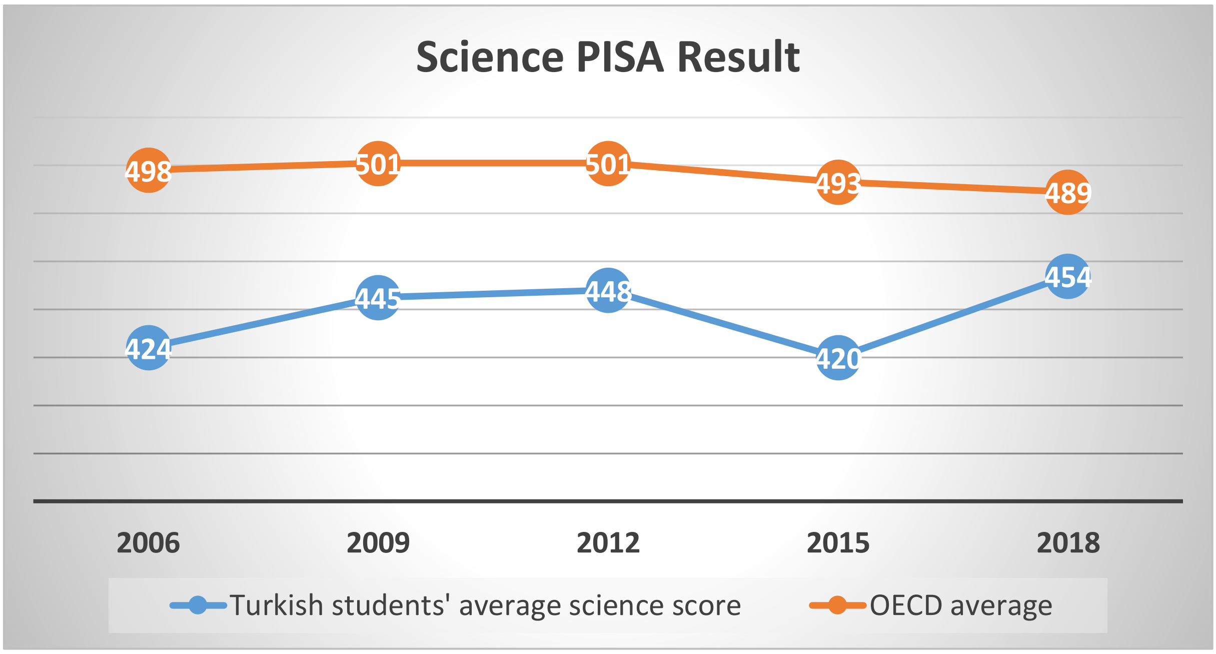


Figure 3. 7: Average science scores of Turkish students in PISA F tests between 2006 and 2018 (Adapted from Çelik et al., 2018; OECD, 2018)

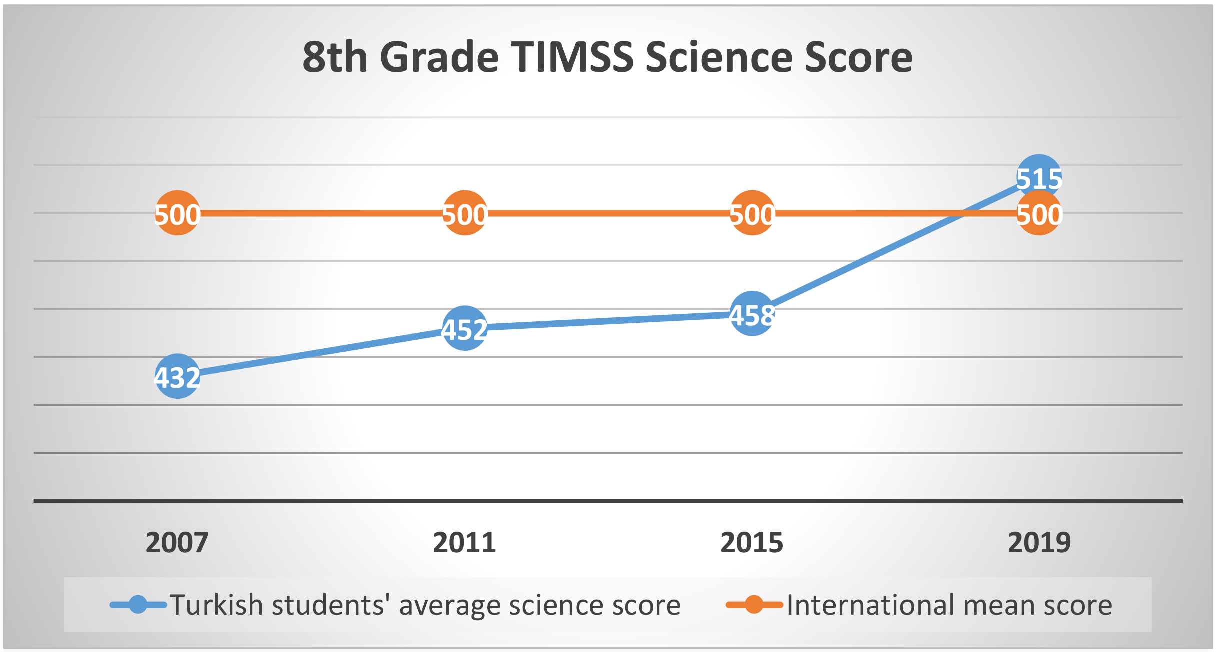


Figure 3. 8: 8th grade Turkish students' TIMSS science scores between 2007 and 2019. (Adapted from Çelik et al., 2018; TIMSS, 2019).

3.10.2 Teacher Training in Turkey

In 1999, a turning point in Turkish teacher education occurred under the National Education Development Project (NEDP) funded by the World Bank (Grossman, Onkol, & Sands, 2007). The NEDP project initiated a Postgraduate Certificate in Education (PGCE) as a new training policy for graduates who had finished 4-year degree programmes. Prospective teachers who graduated from faculties of education that included courses relating to pedagogy became teachers automatically. Those who graduated from faculties of arts and science at universities needed to attend a 1-year non-thesis PGCE programme. Within a 1-year programme, prospective teachers take pedagogy classes and teach in schools on placement. On successful completion, the PGCE is awarded (Deniz & Sahin, 2006).

3.11 Conclusion

This chapter examines the expectations nations have of their teachers and introduces the components necessary for great teachers. Current teacher preparation methods in many countries are based on a deficit model that emphasises supplying prospective teachers with the knowledge thought necessary to function as teachers, along with a 'master-apprentice' structure to create classroom teaching practices. The effect on student accomplishment is variable. International evidence indicates that some well-funded jurisdictions (England) perform at or below the national average. The document analysis examines research findings exemplifying great teacher and identifies elements that seem to be consistently crucial for developing them.

Some nations in this study seek to decentralise education. For example, Israel's 'Pedagogical Horizons for Learning', South Korea's 'Master Teacher' model, and England's 'Educational Excellence Everywhere' initiatives set out to establish strong schools in which teachers lead on their own learning and develop their materials with the help of PD.

Since 2010, the UK's government has sought to improve England's education system. Although English students performed well in international assessment tests, England lags behind East Asian countries. This situation resulted in the DfE implementing innovations and initiatives to improve English pupils' achievement. Ambitious reforms like 'Educational Excellence Everywhere' and the spread of MATs across the country have generated significant progress. For example, the number of students taking core academic subjects at GCSE has increased (DfE, 2016).

Since 2007, Israeli governments have made progress in generating qualified teachers, who in turn improve their students' achievement in international assessment tests. The 'Pedagogical

Horizons for Learning' was a big movement to deliver quality education for teachers and students. This reform has impacted students' achievement. One study showed that Israeli students' mathematics test scores have risen by 0.15 standard deviation (Reingewertz & Shany, 2016).

Overall, three nations (England, Israel, and South Korea) in this study seem to be applying reforms which could act as a guide for Turkey on how to improve education in general and teacher education in particular. This comparative case study may therefore indicate ways of developing great teachers via effective PD. The next chapter explains how those nations' approaches to PD were investigated through a multiple-case study.

Chapter 4: Methodology

"Qualitative research is an effort to understand situations in their uniqueness as part of a particular context and the interactions there".

-Patton, 1985, p. 1

4.1 Introduction

The previous chapter provided a brief account of the nations investigated in this study. This chapter explains how the research questions (RQs) (see chapter 1) were answered through empirical data collection. Section 4.2 provides an overview of the methods used in the study. Section 4.3 provides a timeline for the study. Section 4.4 describes the rationale for adopting a comparative case study research design. Section 4.5 gives information about the pilot study. Section 4.6 discusses ethical issues and consent. Section 4.7 explains access to the research sites. Section 4.8 describes the researcher's role in the study. Section 4.9 provides an overview of the selection of the participants. Section 4.10 discusses the data collection methods for the main study. Section 4.11 explains how data was analysed. Validation of findings is discussed in section 4.12. The chapter ends with a summary, in section 4.13.

4.2 Research Matrix

The main purpose of this study is to examine how great teacher in educational settings is perceived in four jurisdictions; ways in which great teachers develop through professional development (PD). Table 4.1 provides a quick overview of the study's RQs and data sets.

Table 4. 1: Research Matrix

Research questions	In what ways are the educational systems of four nations (England, Israel, South Korea, and Turkey) providing teacher PD that contributes to their teachers' practices?	In what ways is the notion a 'great teacher' perceived in science teacher education in these four nations?	How and why (if at all) do teachers gain wise educational judgement/practical wisdom?
Aim	To investigate how PD contributes to teachers' practice in four countries (their similarities and differences)	To investigate teachers' perceptions of being great teacher in four nations	To investigate how and why (if at all) teachers gain wise education judgment/practical wisdom
Analysis	• Thematic analysis was utilised to identify themes and patterns (Braun & Clarke, 2006).	• Thematic analysis to identify themes and patterns coding (Braun & Clarke, 2006) • Document analysis (Bowen, 2009)	• Thematic analysis (Braun & Clarke, 2006)
Data collection methods	• Observation of the PD activity • Semi-structured interview • Classroom observation	• Focus group interviews with groups of 3-4 teachers • Individual interviews with teachers • Classroom observation • Observation of the PD activity • Policy documents	• Classroom observation • Individual interviews with teachers • Collecting teaching materials
Jurisdictions and data	**England:** 10 individual interviews		
	Israel: 10 individual interviews, 3 classroom observations , 4 PD activity observations		
	South Korea: 10 individual interviews, 3 classroom observations, 4 focus group interviews, 6 PD activity observations		
	Turkey: 10 individual interviews, 3 classroom observations		

4.3 Research Timeline

The study took place in two main phases: a document analysis to understand how PD plays an important role in developing great teachers, followed by data collection in South Korea, England, Israel, and Turkey through semi-structured interviews, focus groups, and observations of PD activities and classroom teaching. The timeline for the research's stages is presented in Table 4.2.

Table 4. 2: Research Timeline

Year	Month	Activity	Objective	Expected Completion Date
2018	January-December	Initial reading about teaching excellence	To gain insight about how excellence in teaching is presented in the literature	Ongoing
	January-June	Selection of nations for the main study	To understand how teaching is perceived in other nations	June
	December	Ethical approval	To increase the legitimacy of the research findings	Gained 19 December
2019	January-September	Initial reading about PD	To investigate how different countries approach PD and develop PD activities for science teachers	Ongoing
	January-September	Research design	To develop research questions, utilise methods, and understated how to analyse data	September
	February-July	Document analysis	To provide contextual information	July
	August	Pilot study I (individual interview questions)	To test the data collection tool	August
	September	Pilot study II (focus group interviews and PD)	To test the data collection tool	September
	September-November	Data collection in South Korea	To grasp what teachers in South Korea think about teaching excellency	November
2020	November-December	Ongoing reading about PD	To update myself about recent developments in teacher education and PD	Ongoing
	January-February	Data collection in Israel	To understand Israeli teachers' stance about how to become a "leader teacher"	February

	Mid-February- Mid-March	Data collection in Turkey	To grasp what teachers in Turkey think about teaching excellency	Mid-March
	Mid-March- July	Analysing interview data from South Korea, Israel, and Turkey	To produce the initial results	July
	July- December	Revisiting literature and work on theoretical framework	To update information in relation to teaching excellence and CPD	December
2021	January-Early March	Data collection in England and analysis	To understand what teachers in England think about teaching excellency	March
	February	Revisiting research design and methodology	To shape methodology based on the latest update related to data collection tools	Early March
	March	Analysis of classroom observations and PD observations	To understand how teachers practice their knowledge expertise	December
	March	Analysis of data collected from England	To understand how teachers in England think about teacher excellency	June
	June-December	Creating first draft Writing up dissertation	To prepare the thesis for sending it to my supervisor	December
2022	January-August	Reviewing and revising the thesis	To prepare for the Viva and proofreading	August
	November	Viva		07.11.2022

4.4 Research Design

This study is interested in how teacher PD contributes teachers' personal and professional qualities and practice in four nations (RQ1). The research also explored both the ways in which great teaching and great teachers are perceived and factors influencing the development of great teachers (RQ2). To understand teachers' perspectives, opinions, and thoughts about "great teachers" in detail and to grasp a sense of the trajectory over time towards becoming a great teacher. I am further interested in examining how teachers develop their practical wisdom practices in this regard looking through the perspective of the notion of practical wisdom (RQ3).

4.4.1 Research paradigm: Qualitative research and interpretivism

Understanding how individuals interact with one another to construct meaning within a time and context is central to qualitative research (Merriam, 2002). Qualitative research is usually associated with an interpretivist/constructivist paradigm, an approach which attempts to understand phenomena from individuals' perspectives by focusing on interactions between individuals and their historical and cultural contexts (Norwich, 2019). The interpretivist approach affords understanding of multiple interpretations in distinct cultures and contexts (Hammersley, 2013) and offers explanations for subjective reasons and meanings that lie behind social action (Kaplan & Maxwell, 1994). Qualitative research investigates "the views of people involved in the research and their perceptions, meanings, and interpretations" (Holloway & Wheeler, 2002, p. 10).

Experimental design and survey design were inappropriate for this research (O'Reilly & Kiyimba, 2015) because understanding teaching excellence requires in-depth understanding of teachers' perceptions and interpretations which are difficult to achieve through survey responses (Hammarberg, Kirkman, & de Lacey, 2016). Controlling variables is challenging in experimental studies. In this project, the extent of variation between jurisdictions meant that this approach would be highly problematic. A qualitative study approach was therefore deemed appropriate to grasp and explore complex issues about teachers and their development in real world settings (Fossey, Harvey, Mcdermott, & Davidson 2002; Merriam, 2002).

The formation of beliefs on the definition of effective teaching and an effective teacher is influenced by a variety of factors (Hamachek, 1999; Larrivee, 2000). Educators function under a wide range of circumstances, each of which has a unique significance in their professional endeavours (Korthagen, 2004). Teachers operate within educational settings where they demonstrate their own characteristics, such as their expertise, convictions, and dispositions. Simultaneously, individuals in this role engage in the management of interpersonal connections with colleagues, school officials, educational authorities, and parents, using diverse strategies such as conversation, effective communication, and ongoing professional growth opportunities. Teachers play a crucial role as they navigate the space where the classroom environment intersects with the larger societal context.

Recognising the unique range of personal experiences that each educator contributes to their profession is crucial, as it cultivates an intricate spectrum of diversity within the field of education. The personal experiences mentioned above are influenced by societal construction, which results in the emergence of a wide array of perspectives. Hence, to attain a comprehensive understanding of teaching as a vocation, it is critical to adopt a multireality perspective that acknowledges the wide range of circumstances that influence the teaching vocation.

For this project, the positivist stance, which is usually associated with a quantitative approach, does not fit (Denzin & Lincoln, 2011). Although quantitative research offers contextual information based on numbers and measurements, quantitative methods are less capable of explaining how meaning-making processes take place (Denzin & Lincoln, 2005). I am interested in understanding (not discovering) the social worlds of teachers in contrasting situations, focusing on their meanings and interpretations. Meanings are socially constructed in particular contexts (Merriam, 2002). As such, knowledge is based on understandings that arise from reflection on events rather than lived experiences (Ormston, Spencer, Barnard, & Snape, 2014).

Even though qualitative methods fit the purposes of this research, the issue of their reliability is subject to criticism (McGloin, 2008). “Reliability refers to the degree of consistency with which instances are assigned to the same category by different observers or by the same observer on different occasions” (Hammersley, 1992, p. 67). Data collection through interviews and observations may be interpreted in multiple ways and can be subject to bias (Mason, 2002). To mitigate this possibility, multiple data collection methods were adopted to increase reliability and generalisability (Leininger, 1994).

The epistemological stance of social constructivism serves the purpose of this study. Interpretivist and social constructivist approaches complement each other because both provide understandings to allow the social actors (research participants and me) to find meanings for education. According to social constructivism, learning is collaborative, and knowledge develops from individuals' interactions through their culture and society (Vygotsky, 1978). For example, Vygotsky (1978) believed that community is central to ‘making meaning’. Teaching and learning involve sharing, negotiating, and socially constituting knowledge. The participants in this study relied on past experiences and knowledge as well as knowledge resulting from interactions and collaboration to understand and make sense of their experiences. They have their own points of view (Merriam, 2002), and so I focused on meanings within contexts.

Framed by a relativist ontology and a subjectivist epistemology, this study adopts a qualitative approach to investigate how the notion of teaching excellence is defined from the perspective of participants in four jurisdictions. Rather than focusing on the features of great teachers, this study attempted to investigate participants’ perceptions of ‘great’ (Denzin & Lincoln, 2011). Hence, a qualitative approach best fitted in this study.

4.4.2 Research Methodology and Process

“Qualitative research makes an effort to understand situations in their uniqueness as a particular context and the interactions there” (Patton, 1985, p. 1). In the present study, my focus of interest, is on how ‘great teaching’ presents itself and how a ‘great teachers’ develop in a particular context. To answer a ‘how’ question, the case study approach was adopted in this study (Crowe, Cresswell, Robertson, Huby, Avery, & Sheikh, 2011; Yin, 2018). This study adopted Stake's (1995, 2006) and Merriam's (1998) case study approach. This approach enables discovery of meaning and understanding of experiences within different cultures. I assumed that reality is multiple and subjective and that it is also constructed socially, experientially, and culturally. According to Flyvbjerg (2011), a case study is "an intensive analysis of an individual unit (as a person or community) stressing developmental factors in relation to environment" (p. 103). Community-based professional development (PD) courses were observed in order to get an understanding of how instructors grow their practices and their bodies of knowledge. According to Wenger (1998), communities are the platforms on which knowledge is transformed via the exchange of experiences and practices by educators with one another. According to Merriam and Tisdell (2015), using a case study technique makes it possible to conduct an in-depth investigation from the points of view of participants in PD courses.

This research uses the Community of Practice (CoP) framework, instead of the Professional Learning Communities (PLC) model, to thoroughly examine the attributes that delineate effective teaching within the realm of scientific education. According to Yin (2018), professional learning communities (PLCs) are recognised as useful frameworks for professional growth. However, the CoP approach offers a more adaptable and natural platform for investigating the complexities of teaching and learning. CoP place significant emphasis on the collaborative exchange of information among persons who possess a shared interest or concern. This strategy fosters a learner-centric and self-directed approach to professional advancement.

The use of a case study methodology, as proposed by Stake (1995), provides an avenue for comprehensive exploration of particular behaviours and occurrences, facilitating a nuanced comprehension of people or collectives. This study goes beyond just recording occurrences and instead seeks to explore the processes and motivations behind a teacher's learning journey. It also examines the intricate relationship between social elements and their influence on teaching practices, drawing upon the perspectives put forward by Bell and Gilbert (1994). This methodology enables a comprehensive and contextually nuanced examination of the attributes shown by exceptional educators in the field of scientific education. This research aims to use the CoP framework in order to recognise the dynamic and collaborative aspects of educational growth. It acknowledges the significance of sharing information and experiences among dedicated educators as a crucial factor in fostering teaching quality.

In the process of performing a case study, it is necessary to use a comprehensive array of data gathering techniques. This research used a thorough methodology that included semi-structured interviews, focus group interviews, observations of classroom and professional development activities, and detailed field notes. The incorporation of several data sources enabled a comprehensive examination of the practices, viewpoints, approaches, and knowledge expressed by the participants. This study aimed to conduct an in-depth examination of the attitudes around exemplary chemistry education and instructors. The inquiry was conducted as part of a concise worldwide comparative case study. It enabled me to highlight the case's real-world context and analyse complex societal concerns (Yin, 2018). A case study was thus a suitable instrument for identifying and illustrating the dynamics behind teachers' pedagogical and practice adjustments.

To compare similarities and differences as well as patterns with regard to teaching excellence, four cases (in England, Israel, South Korea, and Turkey) were investigated for their images of great teaching and developing great teachers (Landman, 2000). Document analysis relating to teacher excellence was undertaken to establish information about interventions those four case study nations have adopted to generate highly qualified teachers. To facilitate comparison between cases, as well as in-depth understanding of each case (Meyer, 2001), England, Israel, South Korea, and Turkey were identified as cases (as explained in detail in chapter 3). Therefore, this research used a holistic multiple-case design with single unit of analysis that aims to define a common explanation what great teaching is, although the cases differ from each other in their detail (Yin, 2018). All four cases demonstrates an understanding of developing great teachers through PD in England, Israel, South Korea and Turkey respectively (Figure 4.1).

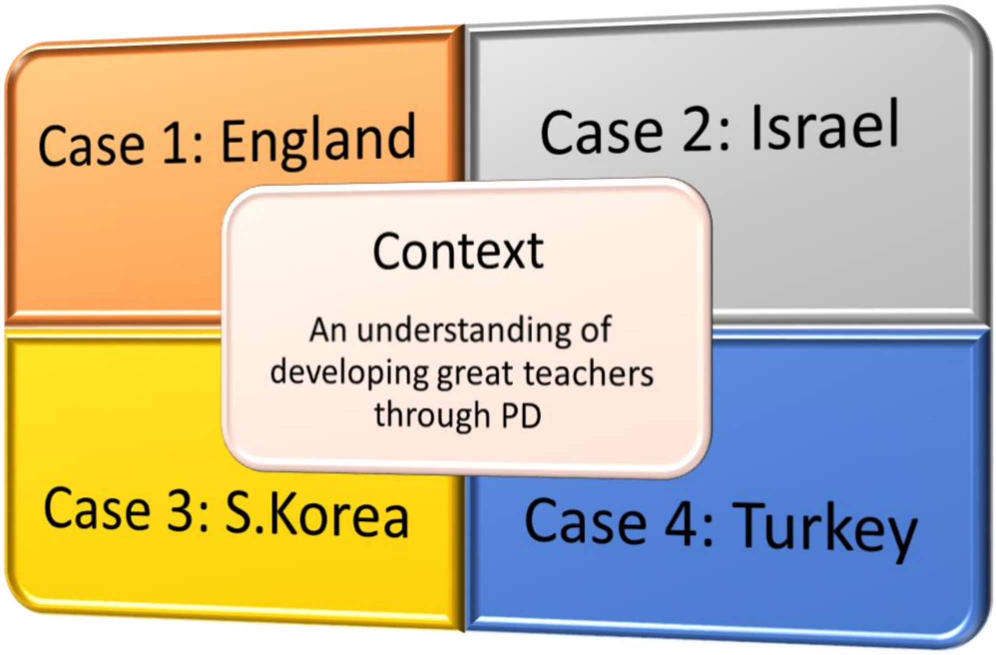


Figure 4. 1: A holistic multiple-case study design
Note: Adopted from (Yin, 2018)

Multiple-case data is often considered as persuasive, and multiple-case research as a whole is consequently considered as powerful. Therefore, I was able to analyse the research questions by employing understanding of being a great teacher through PD as a main case and four sub-cases from four distinct parts of this case. Each case in this research gave an in-depth examination and extensive description. The fundamental purpose of this research was to obtain a knowledge of the phenomena by selecting an multiple case (Yin, 2018). The multiple case study research design is a powerful instrument for delving into the details of a single case, which is the development of great teachers in different jurisdictions (Yin, 2018). It also provided me with the chance to answer the research questions from a variety of angles on this case. As a result of these four multiple cases, it was possible to learn how teachers develop their pedagogy in different jurisdictions, whether their practices differ or are the same depending on the goals and objectives of teaching chemistry, and whether their teaching style and practical wisdom shift when they participate in CoP.

Figure 4.2 illustrates the sequence of the research process. It incorporates the theoretical framework explained in chapter 2, the study's methodological approaches, and its research design. My framework depicts the relationship between the theoretical framework of CoP, evidence in the form of dimensions of experiences required to address the research question, the tools of focus group interview, semi-structured interviews, and observation as means to obtain the evidence. The features of Figure 4.2 are discussed next.

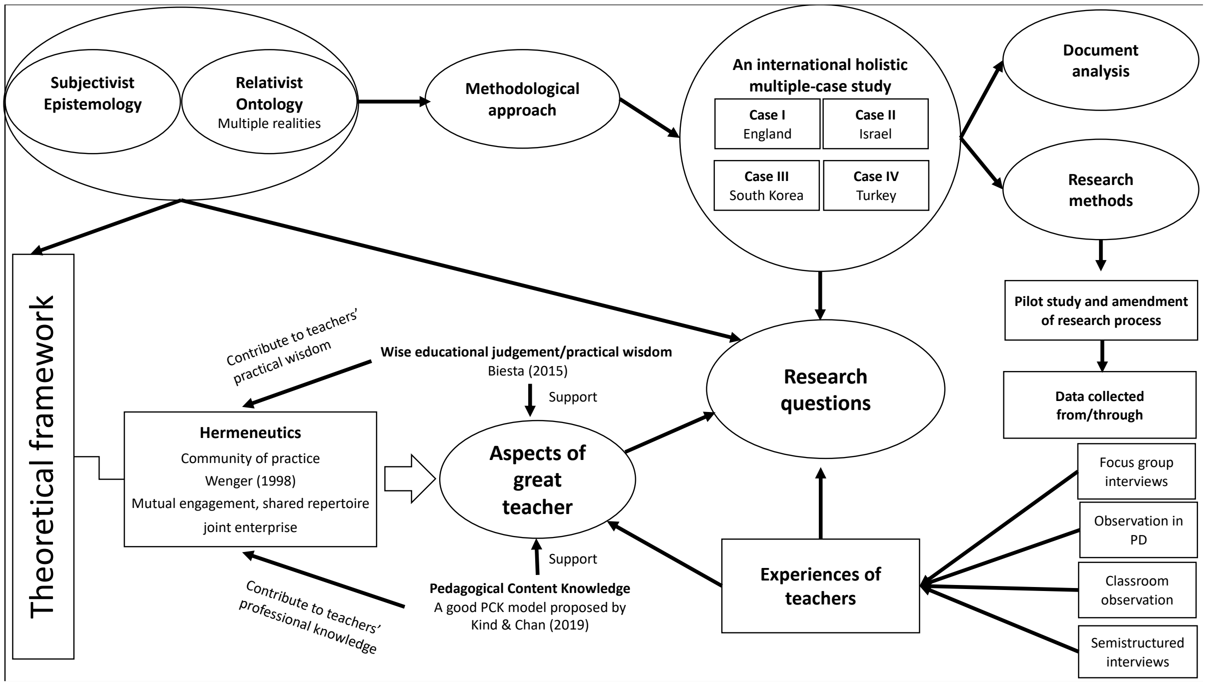


Figure 4. 2: Framework of research process

4.5 Pilot Study

The pilot study took place between August and October 2019. It was conducted to: verify themes revealed in the documents analysis; develop data collection tools; amend the research process; and develop a frame for analysing data. The pilot study contributed to the development of the research methods and permitted revisiting of research foci (Yin, 2003). The pilot study took place in two phases: individual interviews to understand the notion of great teacher; and attending a PD course to understand ways in which PD impacts participants' teaching and learning. The data collection tools used included interviews, observations, and focus groups. Questions were later adapted for the four nations' native languages to eliminate possible misunderstandings.

4.5.1 Pilot study of individual interviews

Semi-structured interviews were used to investigate teachers' thoughts and opinions about teacher excellence (Patton, 1990). Interview questions (see Appendix 1) were trialled with four teachers from England and South Korea (two from each country) between August and

September 2019. A draft interview schedule is shown in Appendix 2. The schedule was designed to probe the notion of great teaching and how to develop great teachers as well as how PD impacts practice. The sample of an interview transcript (pseudonyms Ava) from England is available as Appendix 3. Transcripts were analysed using thematic analysis (Braun & Clarke, 2006) based on themes (CoP, PCK, and PB&V) which emerged from the document analysis (see Chapter 3).

The English teachers' interview data showed that the terminology used in the interview was unclear. Teachers were unfamiliar with the term 'virtuoso teacher'. This finding led me to replace 'great teacher' with a readily understandable term. The question sequence was also redesigned, as I recognised that some interview questions were too similar, which created repetition. Some interview questions and explanations during the interview generated interviewer bias, as they were overly leading in nature. Thus, some changes were made postpilot.

The pilot study afforded an opportunity to generate follow-up questions, which enriched the interview data. The modified schedule was trialled with two teachers in South Korea. The revised interview schedule is shown in Appendix 4. The Korean teachers showed that there was no difficulty in understanding the terms, and the question sequence seemed fine. However, another issue, translation, emerged. Based on feedback and with help from two native Korean speakers, the interview questions were modified for the main study.

The pilot study findings revealed that the research tools lacked clarity and introduced some bias and subjectivity and that the narrative line of the interviews was distorted by the order of the questions. However, the pilot study also indicated that I was on the right track. For example, Ryan emphasised one characteristic of a great teacher when he said:

> [the] teacher needs to judge a particular situation and know how to approach different students. You know, you might have 20 to30 students in the class. Each of them has individual characteristics so it is important to know how to approach them what they need to know and what level to teach, how fast to go, which questions to ask. (Ryan, 2019)

Ava, who was an advanced skill teacher (AST) pointed out that being a great teacher was related to experience. Ava said:

> It is an experience matter you know; every single lesson you teach is not the same. So, the more lessons you teach, the more resilient you become and the more aware of misconceptions and where students struggle and what students find easy, so you can almost predict what the students are going to be able to learn but you cannot do it if you are not enough experienced on those subjects. (Ava, 2019).

4.5.2 Pilot study of focus group interview

Focus group interviews aim to collect high-quality data in a social context (Patton, 2002). Primarily, they help to understand a specific problem from the viewpoint of the research participants (Khan & Manderson, 1992). The method aims to obtain data from a purposively selected group of individuals rather than a statistically representative sample of a broader population. Focus groups provide “a rich and detailed set of data about perceptions, thoughts, feelings, and impressions of teachers in their own words” (Stewart & Shamdasani, 2014, p. 140). The purposive approach was deliberately selected for conducting focus group interviews in order to achieve a high level of precision and relevance in collecting insights from participants who possess extensive knowledge of the education systems in England, Israel, South Korea, and Turkey.

On the other hand, the pragmatic perspective places emphasis on the practicality and real-world relevance of the research. Within the context of this paradigm, focus group interviews are widely regarded as a highly effective method for recording authentic real-life experiences and gaining valuable insights from those who possess a deep understanding of the subject matter. The research acknowledges the distinct significance of the genuine and contextually comprehensive data that educators, who are essential stakeholders in the education systems being examined, can offer. The aforementioned methodology highlights the dedication of the study to provide valuable insights and policy implications that are of practical significance to educators, policymakers, and the international educational community, with the goal of influencing tangible practices and policies in the real world.

Focus group discussions involve a researcher assembling individuals to discuss specific topics. The aim is to draw on participants’ complex personal experiences, beliefs, perceptions, and attitudes through moderated interaction (Cornwall & Jewkes, 1995; Hayward, Simpson, & Wood, 2004).

The inclusion of focus groups was motivated by the need to examine the progression of expertise development among instructors who participated in the same professional development activities (Breen, 2006; Nyumba, Wilson, Derrick, & Mukherjee, 2018). The final focus group discussion included two distinct tasks, as shown on Appendix 5. The first job entailed engaging in a discussion centred around various claims, while the subsequent task required delving into a discourse on terminology pertaining to the concept of teacher excellence. On October 17, 2019, after to a professional development course, a focus group consisting of four chemistry professors was implemented in South Korea. The obtained data is available in Appendix 6.

The findings presented in this study revealed that the remarks made were characterised by vagueness, leading participants to express inquiries, ultimately exerting a negative impact on the overall dynamics of the group. Furthermore, the manner in which the work was presented caused confusion for the individuals. The input I received prompted me to modify my approach in conducting the focus group. The modified focus group assignment is shown in Appendix 7. Additional adjustments were made in accordance with the findings from the preliminary investigation.

4.5.3 Pilot study of classroom teaching

According to Ormston et al. (2014), observation is the most effective method for gaining an understanding of what occurs in the classroom. After developing the Oregon teacher observation technique, I put it through its paces in Soun-Mi's grade 9 physics class in South Korea, where she was instructing students aged 15 to 16 on the "Understanding of light and other forms of energy" unit. On Wednesday, October 23, 2019, an observation of a classroom was carried out. I had a conversation with her before the observation in the classroom and went over the goals of the research with her. Together with Soun-Mi, I went to her classroom ten minutes before the start of the lesson to investigate the possibilities for positioning the camera. She took the time to introduce me to the other students and discuss consent concerns before she began her lesson. Every single kid in the classroom gave their permission for the class to be filmed on camera. After that, Soun-Mi started working as the instructor for her class. There were a total of 27 students enrolled in the course. The lesson lasted for a total of 45 minutes. The PCK model that Kind and Chan (2019) developed was used so that

Soun-Mi's PK and CK could be analysed. The results of the pilot project demonstrated that the positioning of the camera was critical to accurately record a teacher's movements as well as their interactions with the pupils. It was also vital to me to introduce myself to the kids and get their feedback on who I am.

4.5.4 Pilot study of professional development

Teachers' knowledge and practices often develop over time. A PD course may improve teachers' decision-making and judgement abilities through collaboration with knowledgeable and experienced colleagues. Observations of PD activities give deep understanding of how great teachers develop and how interactions between teachers impact their knowledge. My observation protocol was generated on the basis of Kind and Chan's (2019) PCK model. Before the PD began, I met with Sung-Sook, who is a chairperson of Shingwaram. She provided general information about the process of PD. When all the teachers had arrived, she introduced me to them. I then informed them about the purpose of the study. Consent matters were explained to them. All the teachers agreed to being videoed. The trial observation was conducted on 10 September 2019, with the participation of 23 science teachers in South Korea. I sat at the front desk with two other teachers. A tripod-mounted video camera was positioned at the front of the room to facilitate observation of the presenter. The professional development (PD) programme was divided into two sessions, spanning approximately 2 hours and 30 minutes in total. Each session encompassed a presentation on the subject matter, followed by hands-on activities. Based on the findings of the pilot study, it was determined that the camera placement should be at the rear of the room to enable comprehensive observation of both presenters and teachers. This adjustment was deemed necessary to capture the dynamics of teacher interaction and collaboration.

4.6 Research ethics and consent

This research received ethical approval from Durham University's School of Education Research Ethics Committee on 19 December 2019 (ED-ETHICS E.D., 2019) (see Appendix 8). I referred and adhered to the Ethical Guidelines for Educational Research published by the British Educational Research Association (2018) in planning and undertaking this project. Ethical issues related to this study can be categorised as informed consent, confidentiality, and anonymity (Gibbs, 2018). Throughout the data gathering process, the ethical guidelines published by the Academy of Social Science (AcSS, 2015) were adhered to. Informed consent ethics and other relevant ethical problems are covered in the section that follows.

4.6.1 Informed consent

Adopting qualitative research methods involving human subjects generates responsibilities to protect participants regardless of gender, nationality, class, and national identity. There is also a need to provide information about the nature and scope of the study (BERA, 2018). "Informed consent entails informing the research subjects about the overall purpose of the investigation and the main features of the design, as well as of any possible risks and benefits from participation in the research project. Informed consent further involves obtaining the voluntarily participation of the subject, with his or her right to withdraw from the study at any time, thus counteracting potential undue influence and coercion" (Kvale, 1996, p. 112).

When conducting the individual interviews and focus groups, the researcher gave the participants some brief information about the study (see Appendix 9). After the PD session, I met teachers who wanted to volunteer for this study. Having decided on interview dates, they read and signed the consent form (see Appendix 10). The researcher and a colleague delivering the PD programme informed participants about videorecording. Once permission was received, the audio- and video-recording of PD activities were completed. Permission was obtained from students' families for classroom observations. Throughout the data collection in South Korea, participants granted their consent. However, in Israel and Turkey due to local constraints, I collected classroom observation data through audio-recording only. Anonymity of individuals was assured by using pseudonyms throughout (see Appendix 11). The chosen names all begin with the same letter of the participating country's name.

4.7 Research sites

To gain access to research sites, I began by contacting a professor at Daegu University, South Korea. He introduced me to the Chairperson of the *신과람 (Shingwaram),* a Community-based PD established by volunteer science teachers. The PD programme offered there is one of the most well-known, nonprofit courses in Seoul, South Korea. The programme provides science teachers with instructions, materials, and hands-on activities. Appendix 12 provides a description of what the Community-based PDs contain. To gain access, I asked the programme coordinator if I could conduct nonparticipant observations each Tuesday.

Shingwaram is a nonprofit volunteer-based programme for mainly secondary science teachers. Founded in 1993, *Shingwaram* has over 140 members based in Seoul, Incheon, and Gyeonggi Province in South Korea. The Community-based PD is conducted every Tuesday evening (18:00 to 20:30) at the Seoul National University of Education laboratory (Table 4.3). The sessions present experimental and teaching methods and conduct various hands-on activities.

I followed the same process in Israel, where I conducted my second field trip at the Weizmann Institute in Rehovot, so I could attend PD activities. This provides teachers with subject-specific (chemistry) and generic PD. This PD programme also provides chemistry teachers with instructions, materials, and hands-on activities. Description of what the PDs contain is provided in Appendix 13.

The Weizmann Institute is a national collaboration centre for chemistry teachers. Founded in 1969, the centre aims to reach all seventh to twelfth grade science teachers teaching 14-19-year-old students in Israel. That group comprises about 9000 teachers. The fieldwork was conducted at the Weizmann Institute in Rehovot. The course is held every 2 weeks on Tuesday from 18:00 to 20:30 (Table 4.3).

I conducted my penultimate field trip in Turkey using personal contacts to gain access. My last field trip planned to collect data at the *National STEM Education Centre, York,* in the UK. The centre provides science teachers with on-line and off-line PD. However, the Covid-19 pandemic intervened and prohibited attendance.

Table 4. 3: Research sites

<table>
<tr><th>Professional Development</th><th>Access Date</th><th>Session</th><th>Duration (minutes)</th></tr>
<tr><td>The Shingwaram (South Korea)</td><td>10.09.2019 ~ 29.10.2019</td><td rowspan="2">2 sessions</td><td rowspan="2">75 for each session</td></tr>
<tr><td>The Weizmann Institute (Israel)</td><td>15.01.2020 ~ 29.01.2020</td></tr>
</table>

4.8 My role in the research process

I assumed the role of a nonparticipant observer (Ciesielska, Boström, & Öhlander, 2018; Hammersley, 2007) of science teachers' interactions and activities during their PD sessions. To an extent, observation of PD programmes helped to shape the study's interview questions. During the semi-structured interviews, I raised questions about observations made and how activities would impact teachers' practice. My intention was to explore how PD courses prompted teachers to develop knowledge and instructional strategies. I observed the activities, behaviours, and interactions of those science teachers who volunteered for my study.

I attended the PD, then conducted focus group interviews, individual semi-structured interviews, and classroom observations. The rationale for attending the PD programme first and undertaking classroom observation next was to understand whether science teachers applied any new learning in their classrooms. In South Korea, all interviews were conducted face-to-face. In Israel, five science teachers opted for face-to-face interviews; three opted for interviews conducted through email; and two interviews were conducted by telephone. In Tukey, nine interviews were face-to-face and one was conducted via Skype. In England, nine interviews were conducted by telephone and one via Skype.

4.9 The teacher participants

This research was carried out at the high school level (ages 14-18) in England, Israel, South Korea, and Turkey, with the goal of determining how to become a great teacher and how Community-based PD impact teachers' practice. This level of study was selected because it suited both the conditions of my scholarship (I was given this scholarship to pursue a PhD at the high school level in line with the Turkish educational system) and my prior experience as a high school chemistry teacher in Turkey. The community-based PD and participants were chosen based on their volunteer participation and convenience sampling (Silverman, 2013). The study employed teachers who had a trajectory in community-based PD over time. The population for this research comprised science teachers (the majority of chemistry specialists). Additionally, in many countries, results of international comparative assessments, namely TIMSS and PISA have prompted some rethinking of the goals and pedagogy of science education (Anderson, Chiu, & Yore, 2010; Bybee, Fensham, & Laurie, 2009). Studying and understanding the development of teachers may aid in bringing about improvements to science education and impact societies positively.

A participant's number of years of teaching experience was a key variable for inclusion in this study. I recruited experienced subject specialist teachers so that I could attempt to grasp the trajectory of their chemistry teaching experience over time. Data was collected from a volunteer sample of 40 science teachers of the 14-18 age group (10 teachers for each country) who had at least 5 years of teaching experience and attending PD courses. This study focused on science teachers who teach 14-18-year-olds because many studies in relation to excellence in science teaching and PD focus on secondary level education.

4.10 Data generation for the main study

This study used a variety of methods to generate data; these were summarised in section 4.2. The nature of the case study approach requires a multimethod approach (Stake, 2005; Yin, 2018). Hence, the study began with a document analysis and literature review. Thereafter, the comparative case study was conducted utilising multiple data sources: focus group interviews, semi-structured interviews, and classroom-based and PD activity observations.

Communities of Practice (CoPs) are vibrant spaces where educators get together to share their experiences and exchange information, but also to have meaningful conversations and communicate in ways that are based on mutual understanding. In this setting, instructors work hard to improve their methods and so further their professional growth as educators.

The capacity to learn new things and improve professionally is a key component of what makes a successful teacher. In order to support educators on this path, CoPs are essential. Through the provision of a collaborative learning and information sharing platform, CoPs allow educators to improve their pedagogical practices, instructional strategies, and awareness of changing trends in education. These are essential elements that go into being an excellent instructor.

The learning objectives of the students are impacted by CoPs in practice. CoPs foster the development of excellent instructors, who are better able to provide memorable and productive learning experiences. They have the ability to modify their methods of instruction to better meet each student's unique requirements, which will enhance the learning process. Teachers may adjust and innovate in response to the always changing needs of education via the interactions and insights obtained in CoPs. This will eventually improve the quality of teaching and, therefore, the learning experiences of their students.

Semi-structured interviews with master teachers in South Korea, leader teachers in Israel, and experienced teachers in Turkey and England permitted deeper understanding of how the notion of teaching excellence is defined from the participants' perspectives. Focus group interviews were conducted to understand factors that impact development of great teachers. One of this study's aims is to understand how development is achieved and what it looks like from a practice-based perspective.

Lastly, classroom observations were done to understand how great teachers impact each other's professional learning. In total, 40 semi-structured interviews, 10 PD observations, four focus group interviews, and nine classroom observations were completed between September 2019 and March 2021. The Covid-19 pandemic caused changes in the data collection plans and limited access to teachers. The next section gives detail information on the kinds of methods that were applied to address the study's research questions.

4.10.1 Semi-structured interviews

Semi-structured interviews were conducted with experienced science teachers who had attended PD activities throughout their career. This study aimed to compare and contrast the impact of PD on teachers' development and growth in the selected countries. A standardised interview schedule makes it easy to compare respondents' answers (Bryman, 2012). Teachers were asked a series of questions in the same, fixed order, followed by follow-up questions. Interview questions were categorised in three sections designed to cover themes from the document analysis. The teachers were asked 10 questions. The first four questions were designed to understand the teachers' trajectory on PD and teacher knowledge; the next four questions related to teacher beliefs and virtues around teaching science. The last two questions revolved around teachers' perspectives on what makes great teacher.

In each country, 10 teachers who attended PD programmes were invited to participate. The first field trip was conducted between September and December 2019 in South Korea. Audio recordings of the interviews took place individually in the school, university, or PD course. Each interview took 30 to 65 minutes. The interview process included brief information about myself and the study as well as consent issues along with asking the main interview questions and concluding the interview. I followed the same process in Israel (between January and February 2020), Turkey (between February and March 2020), and England (between February and March 2021), where I conducted my second, third, and fourth field trips, respectively. The interviews with teachers aimed to understand not only their perspective on PD, teaching practice, and great teaching, but also their professional background and experience. The demographic information on South Korea, Israel, Turkey, and England summarised in Table 4.4 included the participants' gender, years of teaching experience, subject they teach, and career pathway.

Table 4. 4: Participants’ demographic information

Name	Gender	Higher degrees and current position	Subject and years of experience	High School type General / Science /Vocational	Duration Minutes	Date	Locus
So-Yeon	Female	Master’s in chemistry, PhD in education	Chemistry 17	Science	55	11.10.2019	School
***Seon-Mi Chairperson**	Female	Master’s and PhD in education (Master Teacher for 8 years)	Chemistry 31	General	45	15.10. 2019	PD
***Sang-Cheol Chairperson**	Male	Head of chemistry teachers in school	Chemistry 31	General	50	18.10. 2019	School
Sung-Sook	Female	Master’s and PhD in chemistry education	Chemistry 28	General	45	22.10. 2019	Course
Si-Eun	Female	Master’s and PhD in science education	Chemistry 14	General	65	21.10. 2019	School
Se-Hoon	Male	Master’s and PhD in science education	Chemistry 28	Science	50	29.10. 2019	
Sang-Woo	Male	Master’s in chemistry and PhD (ongoing) in education	Physics 13	Vocational	40	23.10. 2019	University
Su-Mi	Female	Master’s and PhD in science education	Chemistry 26	General	30	11.10. 2019	
Seon-Jun	Male	-	Biology 30	General	30	24.10. 2019	School
So-Ra	Female	Master’s and PhD (ongoing) in science education	Science 12	General	35	11.10. 2019	
Isaac	Male Israeli	Master’s and PhD (ongoing) in science education	Chemistry 10	General	70	20. 1. 2020	University
Ilana	Female Israeli	Master’s and PhD (ongoing) in science education	Chemistry 25	Science	75	21. 1. 2020	
	Female						

Ivana	Israeli (Arab)	Master’s and PhD (ongoing) in science education	Chemistry 23	General	50	28. 1. 2020	
Ioane	Male Israeli	Master’s and PhD in Chemistry	Chemistry 5	General	40	28. 1. 2020	-
Inbar	Female Israeli	Master’s in chemistry	Chemistry 6	Science	45	28. 1. 2020	-
***Irit**	Female Israeli	Master’s and PhD in science education (Excellency award in Israel)	Chemistry 37	General	45	28. 1. 2020	University
Idit	Female Israeli	Master’s in chemistry and PhD in chemistry education	Chemistry 40	General	60	29. 1. 2020	
Ivanka	Female Russian	-	Biology 40	General	-	01. 2. 2020	-
Isabel	Female Israeli	Master’s in biology education	Biology 33	General	-	02. 2. 2020	-
Irene	Female Israeli	Master’s in biochemistry	Chemistry 33	General	-	11. 4. 2020	-
Tolga	Male Turk	-	Chemistry 15	Science	45	24. 2.2020	School
Turgut	Male Turk	-	Chemistry 33	Anatolian	65	25. 2. 2020	
Tuba	Female Turk	Master’s in chemistry	Chemistry 12	Anatolian	30	26. 2. 2020	
Türkan	Female Turk	-	Biology 30	Anatolian	60	26. 2. 2020	
Tülin	Female Turk	-	Chemistry 22	Anatolian	55	27. 2. 2020	
Tanyeli	Female Turk	-	Chemistry 7	Anatolian	35	27. 2. 2020	
Tezcan	Female Turk	-	Chemistry 6	Anatolian	30	27. 2. 2020	
Temel	Male Turk	-	Chemistry 17	Anatolian	30	28. 2. 2020	

***Tamer**	Male Kurdish	Master’s and PhD (ongoing) in science education (Regional Excellency award)	Chemistry 7	Anatolian	65	02. 3. 2020	-
Tuğçe	Female Turk	-	Biology 15	Anatolian	40	282. 2020	School
Emma	Female British	PGCE KS4 science lead	Science (biology specialist) 5	Independent	-	18. 2.2021	Telephone
Elizabeth	Female British	PhD in Education (ongoing) Head of chemistry	Science (chemistry specialist) 12	Independent	45	25. 2. 2021	
Ethan	Male British	PhD in biochemistry	Science (chemistry specialist) 15	Academy	40	15. 2. 2021	
Emily	Female Indian	PGCE	Science (chemistry specialist) 8	State	55	17. 2. 2021	
Eliot	Male Nigerian	PGCE	Science (chemistry specialist) 5	Academy	70	6. 2. 2021	
Erik	Male British	PhD in biochemistry	Science (chemistry specialist) 15	Independent	45	10. 3. 2021	
Eva	Female British	PGCE Head of chemistry	Science (chemistry specialist) 10	Independent	35	3. 2. 2021	
Elena	Female British	PhD in education (ongoing)	Science (biology specialist) 20	Independent	45	18. 2. 2021	
Emilee	Female Bruneian	Master’s in chemistry, Head of chemistry CChem, MCCT	Science (chemistry specialist) 27	Independent	50	15. 2. 2021	
Elisa	Female British	Teach First	Science 5	Academy	40	15. 2. 2021	

4.10.2 Classroom teaching and laboratory observations

Observations of teachers' practice took place in two phases. First, a classroom observation was done to understand how teachers applied theories, pedagogy, and knowledge gained from PD activities. Second, an observation of practical work was done to understand how teachers applied hands-on activities learning from PD courses. Observing teachers' practices enabled me to investigate the ways in which science teachers become a great teacher. In South Korea, Turkey, and Israel, practical work took place in a laboratory.

Documents relating to the lessons e.g., lesson plans, student worksheets, curriculum information, and PowerPoint presentations were collected and discussed with teachers. Documents are important for a case study to provide context (Stake, 1995).

One video camera was set up on a tripod at the back of the classroom or laboratory to catch the teacher's movements and interactions with students, as well as to capture a general sense of the entire class. To capture teachers' voices clearly and their interaction with students, the teachers were wired to an audio recording device. During the classroom observation, notes were taken to use for data analysis.

The Oregon Teacher Observation Protocol (see Appendix 14) and a PCK model proposed by Kind and Chan (2019) were used to guide observations of teachers' professional knowledge and how this knowledge impacts knowledge of students. Types of knowledge observed in this study were pedagogical knowledge (PK), which comprises four subcomponents: i.e., knowledge of instructional strategies, classroom management, organisation of resources and materials, and knowledge of assessment and curriculum and CK, which comprises facts and concepts. Six classroom observations along with three laboratory observations were conducted in Turkey, South Korea, and Israel.

The audio and video recordings of the classroom teaching and laboratory observations were 45 to 120 minutes long. Nonparticipant observation was conducted. This enabled me to see and hear all aspects of the teachers' classroom practice and the students' interaction with them. I sat at the back alone so as not to attract the teachers' and students' attention.

In South Korea, Seon-Mi, Se-Hoon, and Sang-Cheol were observed while teaching alkanes, thermodynamic, and redox reactions, respectively. Each classroom observation took 45 minutes. Laboratory observation took 1 hour 30 minutes. Seon-Mi taught alkanes to tenth grade (15-16-year-old) students. She had 16 students in the classroom; all of them were boys. She grouped students into four groups of four students. Se-Hoon had 20 students, 6 girls and 14 boys. He taught thermodynamics to twelfth grade (17-18-year-old) students. He did not put students into groups. Sang-Cheol taught redox reactions using hands-on activities. There were 14 students in his class, 3 boys and 11 girls. He allowed students to work in a group.

In Israel, Ivanka, Ilana, and Isaac were observed teaching about DNA, density, and chemical equilibrium, respectively. Ivanka's class took 75 minutes; Ilana's class took 1 hour 15 minutes; and Isaac's classroom observation took 45 minutes. Ivanka taught DNA and its structure to twelfth grade students (18-19-year-olds). She had 21 students in total, 10 boys and 11 girls. She separated students into six groups. Ilana taught density to tenth grade (15-16-year-old) students. She had 24 students in her class, 12 girls and 12 boys. They were separated into six groups. Isaac taught chemical equilibrium to eleventh grade (17-18-year-olds). He had 20 students in his class. He also separated students with small groups.

In Turkey, Tolga, Turgut, and Türkan were observed while teaching chemical bonding, chemical bonding in chemistry, and organs in biology, respectively. Tolga's and Turgut's classroom observations took 45 minutes. Türkan's laboratory observation took 1 hour. Tolga and Turgut both taught chemical bounding in chemistry class to ninth grade (14-15-year-old) students. Tolga had 27 students, 11 boys and 16 girls, while Turgut had 28 students, 12 boys, 16 girls. Both teachers did not put students into groups. Türkan taught organs in her biology class to eleventh grade (16-17-year-old) students. She had 24 students in her laboratory, 10 boys and 14 girls. She put her students into six groups. Demographic information on the classes is provided in Table 4.5.

Table 4. 5: Observation outline: South Korea, Israel and Turkey

Observation	Teacher	Subject	Topic	Duration Minutes	Class size	Date
1	Seon-Mi	Chemistry	Alkanes	45	16	28.10.19
2	Se-Hoon	Chemistry	Thermodynamic	45	20	29.10.19
3	Sang-Cheol	Chemistry	Redox Reactions	90	14	30.10.19
1	Ivanka	Biology	DNA	75	21	22.01.20
2	Ilana	Chemistry	Density	75	24	26.01.20
3	Isaac	Chemistry	Chemical Equilibrium	45	20	24.01.20
1	Tolga	Chemistry	Chemical Bonding	45	27	24.02.20
2	Turgut	Chemistry	Chemical Bonding	45	28	25.02.20
3	Türkan	Biology	Organs	60	24	26.02.20

The same observation protocol was applied in each country, although observing teaching of the same topics was not possible due to differences in curriculum presentation. Also, data collection was limited by visiting countries at particular times of year. In England, neither classroom nor laboratory observation was conducted because of the Covid-19 pandemic which closed schools for an extended period from March 2020 onwards and restricted access thereafter.

4.10.3 Professional development observations

The OTOP was adapted to observations of PD activity (see Appendix 15) and was based on Kind and Chan's (2019) PCK 'amalgam'. PD observations focused on five elements, namely knowledge of instructional strategies, classroom management, organisation of resources and materials, and knowledge of assessment, and curriculum and CK and how these components relate to knowledge of students.

I attended PD activities provided by Shingwaram in South Korea. Although led by secondary school science teachers, it also includes elementary school teachers and academics. It is a community-based PD. Shingwaram holds activities to develop teachers' skills and plays an active role in getting students interested in science. Every Tuesday during the semester (from 18:00 to 20:30) teachers gather at the Seoul National University of Education laboratory to present experiment methods and teaching methods and to conduct various activities. Seven observations were conducted in South Korea.

The Shingwaram sessions involved two 70-minute sessions. Each session had a theoretical and practical part. Each week two teachers from different schools presented their projects or a piece of work. The theoretical part was followed by the practical part. There were six to seven groups and each group had four teachers. This PD is generic. Teachers from different expertise areas provided information to other teachers. To gather data, a video camera was installed on a tripod at the back during the theoretical part. For the practical part, the camera was set up on a table where teachers did hands-on activity (a group to video was selected randomly). In addition to video and audio recordings, handouts and activity sheets were gathered as needed for data analysis. A sample of a handout can be seen in Appendix 16.

In Israel, I visited the Department of Science Teaching at the Weizmann Institute, which runs 60 community-based PD for science teachers. The rationale was to understand a PD programme known as 'the fan model'. This involves teachers from all over the country coming to the Weizmann Institute to work with experts and then returning to their regional communities to lead teachers locally. Thereafter, teachers apply their learning in the classroom. Two communities, community-based PD with group leaders and a 'community-based PD close to home' were observed. Four observations were conducted.

The length of the PD was 2 hours 30 minutes in total. The PD had two sessions; each took 70 minutes. As in South Korea, PD had theoretical and practical parts. In the theoretical part, teachers, researchers, and academics collaborated and shared knowledge and created diagnostic tests together. In the practical part, teachers and researchers separated into groups of three to four and did hands-on activities. Handouts and activity sheets were collected for data analysis. A sample handout can be seen in Appendix 17. The observation outline for both South Korea and Israel is summarised in Table 4.6.

Table 4. 6: Professional development observations outline: South Korea and Israel

Observation	Course	Participants	Population	Duration Minutes	Date	Locus
Pilot	*Shingwaram*	Science teachers	23	150	10. 9. 2019	SNU Laboratory
1			22		17. 9. 2019	
2			26		24. 9. 2019	
3			24		01.10. 2019	
4			25		15.10. 2019	
5			25		22.10. 2019	
6			20		29.10. 2019	

1	Teacher community with group leaders	Leader teachers	14	150	15. 1. 2020	Weizmann Institute
2	Teacher community with physics teachers (project-based)	Physics teachers	20		20. 1. 2020	
3	Teacher community close to home	Chemistry teachers	16		22. 1. 2020	
4	Teacher community with group leaders	Leader teachers	21		29. 1. 2020	

In Turkey, I could not attend PD programmes, first because when I visited, no courses were available to attend, and second because PD courses in Turkey occur at the beginning or end of each semester. Some nonprivate organisations in Turkey provide PD courses, but my contacts could not facilitate an invitation for me to attend these. At school level, small communities of teachers gather to collaborate after school, but teachers do not attend them. I could not collect data from PD courses in England due to the Covid-19 pandemic which constrained activities for a lengthy period.

4.10.4 Focus group interviews

In line with the research objectives, focus groups were conducted to gain a sense of the trajectory and experience of teachers who attend and work collaboratively within the same community-based PD in Turkey, South Korea, Israel, and England. Prompts included community of practice (CoP), knowledge (SMK, PK, CK, PCK), and beliefs derived from the document analysis. Key words in relation to teacher excellence and teacher development were discussed.

Although having between six and eight participants is sufficient (Krueger, 2015), some studies report as few as four and as many as fifteen participants (Reed & Payton, 1997). I set up four focus groups in South Korea; each comprised four or five science teachers (see Table 8). This number generated a variety of perspectives and enabled easy management of the discussion.

Focus groups did not take place in the other nations due to local issues relating to gathering teachers at the same time in one place. In England, the Covid-19 pandemic impacted focus group data collection.

Table 4. 7: South Korea: Focus group interview information

Focus group	*Number of Participants*	*Date 2019*	*Duration minutes*	*Locus*
Pilot study	4	17. 9	40	PD course
1	5	24. 9	45	
2	4	11.10	75	School
3	5	15.10	50	PD course
4	4	22.10	30	

4.11 Data analysis

The preliminary stage of data analysis included the transcription of lessons and professional development activities recorded in audio and video formats, as well as the transcription of interviews conducted in audio format. The researcher used deductive and inductive coding techniques throughout the process of formulating initial codes (Braun & Clarke, 2006; Fereday & Muir-Cochrane, 2006). The data obtained from the semi-structured interviews and focus group interviews underwent a thematic analysis and coding process. This analysis and coding were focused on certain topics, namely Community of Practice (CoP), Pedagogical Content Knowledge (PCK), and Pedagogical Beliefs and Values (PB&Vs). These themes were determined via a comprehensive examination of the literature and document analysis conducted in chapters 2 and 3.

This research adopts Wenger's (1998) conceptualization of Communities of Practice (CoP), which not only clarifies the CoP's subcomponents but also illuminates the qualities that lead to the formation of a good teacher. Educators may improve their instructional strategies and pedagogical abilities thanks to CoPs, which encourage cooperative learning and information sharing. The development of traits like flexibility, receptivity to new ideas, and a dedication to continuous professional development inside CoPs is essential for producing outstanding teachers.

Additionally, the idea of a good teacher is inextricably linked to Kind and Chan's (2019) study of the Pedagogical Content Knowledge (PCK) model. It is possible to get insights into the complex nature of successful teaching by comprehending the many types of professional knowledge that teachers possess, as shown by their research. A superb teacher is one who has both the pedagogical abilities to successfully communicate their extensive subject matter knowledge to their pupils and the ability to positively influence their learning. So, by looking at how various knowledge kinds affect students, the research inadvertently investigates the characteristics of a good teacher by highlighting the significance of good pedagogy.

Furthermore, the study's use of Arthur et al. (2015) notion of virtue characteristics provides a prism through which to see the subcomponents of professionalism, beliefs, and virtues (PB&V) that are essential to the composition of a successful teacher. A great teacher is shaped by these subcomponents, which include qualities like ethics, honesty, and a dedication to the welfare of children. Thus, in light of the varied nature of successful teaching and the characteristics that make a great teacher in the framework of CoP, this study focuses on the character virtues and values that underlie the attributes of a great teacher.

4.11.1 Translation

As this is cross cultural research, data was collected in English from Israel and England and in Turkish and Korean respectively in Turkey and South Korea (see Appendix 18). Translating from one language to another requires taking translated-related principles into consideration (Sarantakos, 2013). To eliminate bias and exaggeration and increase the validity and trustworthiness of data, adjusting data collection tools to be culturally and contextually appropriate for participants' native language is necessary (Birbili, 2000; Chen & Boore, 2010).

In this research, I was responsible for collecting data in a number of languages including English, Turkish, and Korean. This process involved translating data collection tools and then, in the analysis stage, translating collected data from Turkish and Korean into English. 'As both translator and researcher, the quality of translation was influenced by factors such as: the autobiography of the researcher-translator; the researcher's knowledge of the language and culture of the people under study' (Vulliamy, 1990, p. 166). While translating data collection tools and analysing data, free translation was used rather than a literal translation (i. e., translating word by word) (see Figure 4.3). The process occurred in two phases: First, data collection tools were prepared in English and checked by a native English speaker. Thereafter, I translated the documents from source into the target languages Turkish and Korean.

In order to achieve accuracy in resolving issues linked to translation and mitigating the risk of misinterpretations, a meticulous procedure was developed, as seen in Figure 4.3. This methodology included engaging in discussions with two highly skilled individuals who are native speakers of the Korean language. The scope of these conversations included not only the assurance of the utilisation of educational terminology, but also the examination of grammatical subtleties and language proficiency, in accordance with recognised principles (Bassnett-McGuire, 1980; Brislin, Lonner, & Thorndike, 1973). The preliminary phase was done prior to commencing the pilot project.

Following this, the subsequent stage of the procedure was the conversion of data from Turkish and Korean languages into the English language. Following the collection of primary data from the field, audio transcripts were transcribed in their native languages of Korean and Turkish. After completing this procedure, the transcripts were transcribed into English with great attention to detail. The next part offers a complete overview of the theme analysis methods used for the whole of the collected data.

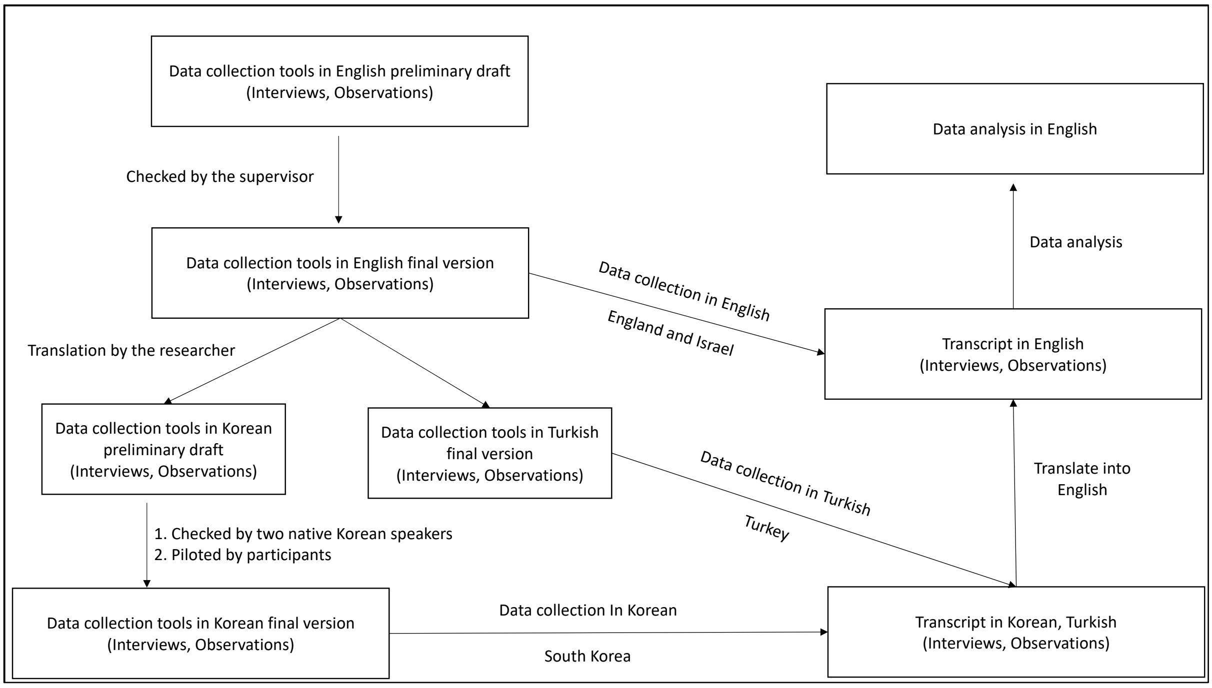


Figure 4. 3: Translation procedures

4.11.2 Thematic analysis

Thematic analysis of the interviews was conducted manually (Gibbs, 2018) to generate, identify, and report patterns (themes) (Braun & Clarke, 2006). To grasp individuals' perspectives and perceptions, thematic analysis is suitable (Nowell, Norris, White, & Moules, 2017). The use of theme analysis facilitated the examination of commonalities and disparities across the four examples, as well as the identification of patterns indicative of exemplary instruction (Boyatzis, 1998). The first stage included the transcription of all the data. The subsequent phase included the generation of initial codes. The codes were derived via a comprehensive assessment of the literature and analysis of relevant documents, including pre-determined themes (also known as a priori themes). These codes were then combined with codes generated from the raw data, leading to the identification and development of early themes (Braun & Clarke, 2006). The inclusion of a priori themes is a crucial factor in expediting the first coding stages (King, 2012). The use of initial codes serves as a first stage in conducting a comprehensive and insightful analysis, as proposed by Boyatzis (1998). Table 4.11 illustrates the methodology used for coding, accompanied by excerpts from transcripts as illustrative instances.

4.11.3 The data analysis of teachers

The dataset to address RQ1, RQ2 and RQ3, The audio recordings of the interviews were analysed to determine how community-based PD influences teachers' practice, their beliefs and qualities that impact being a good teacher, and what constitutes a great teacher. I used the concept of practical wisdom as a lens for investigating teachers' pedagogical development of practical wisdom as a new way to develop teaching practice. Analysis of teacher data took place in three ways: thematic analysis (for identifying differences and similarities between the four nations); of semi-structured interviews; and analysis of classroom observations, PD observation, and focus group interviews.

<u>A template for thematic analysis</u>

<u>Step 1:</u>

Data from the semi-structured interviews was reduced into an Excel spreadsheet. This organised the data, making it manageable and easier to match codes (see Appendix 19).

Step 2:

A preliminary template, (see Table 4.8) was constructed utilising semi-structured interviews in South Korea. Being the smallest data subset made it easier to examine the data thoroughly. Three themes were identified: personal qualities, academic qualities and professional qualities.

Table 4. 8: A preliminary coding template

A priori themes	*Codes*		*RQs*
Professional qualities	1. Collaboration 2. Dialogue 3. Feedback 4. Sharing 5. Unity	6. Organising 7. Activity 8. Exchange 9. Update 10. Social media	2
Academic qualities	1. Misconceptions 2. Modelling 3. Storytelling 4. Micro-macro 5. Diagnostic test	6. Management 7. Tools and equipment 8. Assessment 9. Hands-on 10. Digital literacy	1-3
Personal qualities and beliefs	1. Curiosity 2. Critical thinking 3. Judgement 4. Fairness 5. Humour	6. Love of learning 7. Humility 8. Open-mindedness 9. Perseverance 10. Global citizenship	1-3

Step 3:

Themes were compared across the interview responses of all four nations (South Korea, Israel, England, and Turkey), modified, and used to produce the initial coding template, T1 (see Table 4.9). Another theme generated from the data (that is, an inductive theme), i.e., practical-moral knowledge, passion, and professional behaviour, which did not fit with either theme was added. At the end of this stage, the template (T1) contained a list of codes relevant to the research questions.

Table 4. 9: Modified preliminary coding template (T1)

Themes	Codes		RQs
Professional qualities	1. Collaboration 2. Dialogue 3. Feedback 4. Sharing 5. Unity	6. Organising 7. Activity 8. Exchange 9. Update 10. Social media 11. Trust 12. Mutual-understanding 13. Synergy	2
Academic qualities	1. Misconceptions 2. Modelling 3. Storytelling 4. Micro-macro 5. Diagnostic test	6. Management 7. Tools and equipment 8. Assessment 9. Hands-on 10. Digital literacy 11. Communication 12. Engagement 13. Flipped-learning	1-3
Personal qualities and beliefs	1. Curiosity 2. Critical thinking 3. Judgement 4. Fairness 5. Humour 6. Love of learning 7. Affection 8. Interest	9. Humility 10. Open-mindedness 11. Perseverance 12. Global citizenship 13. Creativity 14. Volunteering 15. Human-oriented	1-3
Practical-moral knowledge	1. Critical reflection 2. Appropriate judgment	3. Decision-making 4. Pedagogical reasoning	1-3
Passion	1. Hope 2. Caring 3. Courage	4. Enthusiasm 5. Interest 6. Dedication	1-3
Professional behaviour	1. Dressing 2. Punctuality	3. Self-discipline 4. Responsibility	1 and 3

Step 4:

The modified initial template, T1 was then applied across the entire data set (that is, including lesson observations, observations in PD activities, and focus group interviews (see summary of focus group interview in appendix 20) to create the final template, T2 (see Table 4.10).

Table 4. 10: Final coding template (T2)

Themes	*Categories*	*Codes*		*RQs*
Community of practice **(CoP)**	1. Mutual engagement	Cooperation Effective partnering	Collaboration	2
	2. Joint enterprise	Coherence for action	Unifying goal Common purpose	
	3. Shared repertoire	Facilitate learning Negotiating meaning	Meaning-making	

Pedagogical content knowledge **(PCK)**	1. Knowledge of students	Misunderstanding Cognitive ability	Noncognitive ability Emotions	1 to 3
	2. Instructional strategies	Teaching technique Scaffolding		
	3. Classroom management	Greetings	Voice Planning	
	4. Organisation of resources and materials	Visual prompts Smart devices and software	Internet	
	Concepts and facts			
Professional beliefs and virtues **(PB&V)**	1. Intellectual virtues	Creativity Critical thinking	Open-mindedness Resourcefulness	1 to 3
	2. Performance virtues	Resilience Determination	Confidence Perseverance	
	3. Civic virtues	Global citizenship Volunteering	Community	
	4. Moral virtues	Fairness Humility Integrity		
Practical-moral knowledge	1. Independent judgement			1 to 3
	2. Pedagogical reasoning	Critically analysing Aspects of active teaching	Enabling connections Instructional decision Reflection	
	3. Insightful decision-making			
Passion	1. Readiness 2. Scaffolding	Willingness to teach and learn Support students learning	Develop new concept and skills	1 to 3
Professional behaviour	1. Self-respect 2. Self-efficacy	Value of teaching Positive thoughts		1 and 3

Six themes were identified namely CoP, PCK, PB&Vs, practical-moral knowledge, passion and professional behaviour. Next, Table 4.11 shows sample coding from transcripts.

Table 4. 11: Coding samples from transcripts

Quotes	Coding
I try to give students some common values like honesty, dignity, moral characters etc. As a chemistry teacher, it is considered that we should just be responsible for delivering chemistry or science knowledge but actually what I try to do is let them	Cultivating moral values of teaching

know about what is going on around us. (Turkey, Teacher)	
I got lot of benefit from a research study group, because in that group, we are doing brainstorming about finding the best and easiest ways in which to deliver knowledge to students. I put my idea on the table and other members of the group also say their opinions and we find a solution… I learned from my colleagues' different experiment methods and teaching aids in our research study group. (South Korea, Teacher)	Link between CoP and teachers' learning
You can teach the same subject with the same knowledge and materials but in a more interesting way like with storytelling, even how we learn to talk. I think storytelling is a good way to teach chemistry… I am just thinking how to tell a better story like if you want to explain about atoms, then you can tell a story. (Israel, Teacher)	Knowledge of instructional strategies

The next step in the thematic analysis was to review, define, and name themes (Braun & Clarke, 2006). Figure 4.4 shows ways in which codes were utilised to generate for the themes.

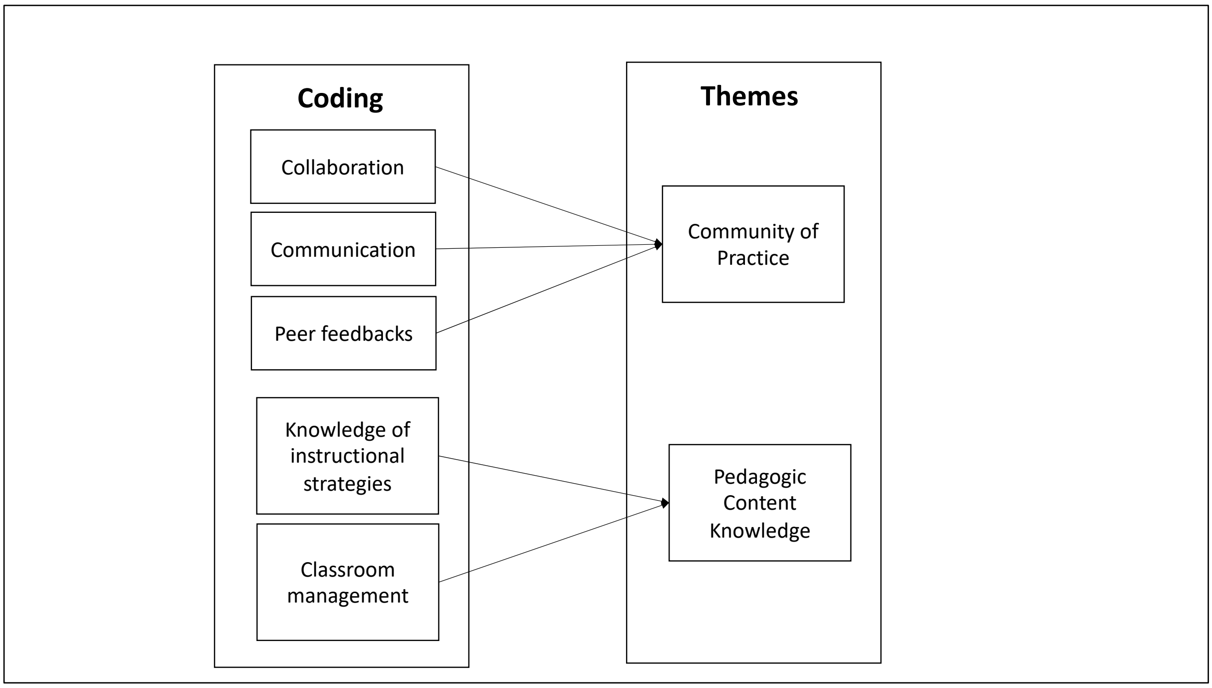


Figure 4. 4: Connection between codes and themes

4.11.4 Data analysis of the teachers' classroom and laboratory practice in chemistry

Another dataset used to respond to RQ2 and sub-questions comprised audio and video recordings of chemistry teachers' classroom practices, practical works, and field notes. The primary goal of the analysis was to determine whether or not chemistry teachers employ PCK in their classrooms. The classroom observation procedure was created to monitor two categories of teachers' professional knowledge and how that knowledge affects students' understanding. In this study, two types of knowledge were observed: PK, which consists of four sub-components: knowledge of instructional strategies, classroom management, resource and material organisation, and knowledge of assessment and curriculum; and CK, which consists of facts and concepts.

Ten items were identified using Kind and Chan's (2019) PCK approach. Looking at video recordings of each lesson and indicating the main phases of these lessons in terms of form, e.g., teacher encouraged students to develop chemical understanding, teacher's CK presentation, different instructional strategies, were used to identify the phases of lesson structure. Each item was described in Table 4.12. See the example of transcript of classroom observation in appendix 21.

Table 4. 12: A framework for identifying the various components of teaching

Codes for different patterns in the lesson	Features of the Patterns / Structures of the Lesson
Stimulating students' interest and curiosity in chemistry	Presented open-ended questions Encouraged discussion of alternative explanations Presented inquiry opportunities for students Provided alternative learning strategies
Encouraging students to develop chemical understanding	Encouraged students to explain their understanding of concepts Encouraged students to explain in own words both what and how they learned Routinely asked for student input and questions
Organising collaborative learning strategy	Organized students for group work Interacted with small groups Provided clear outcomes for group
Promoting growth-mindset	Asked higher level questions Encouraged students to extend concepts and skills Related integral ideas to broader concepts
Assessment knowledge	Pre-assessed students for their thinking and knowledge Helped students confront and/or build on their ideas Refocused lesson based on student ideas to meet needs
Content knowledge presentation	Presented information that was accurate and appropriate to student cognitive level Selected strategies that made content understandable to students Was able to field student questions in a way that encouraged more questions Recognized students' ideas even when vaguely articulated
The usage of instructional strategies	Used multiple methods, strategies and teaching styles to explain a concept Used various materials to foster student understanding (models, drawings, graphs, concrete materials, manipulatives, etc.)
Curriculum knowledge	Integrated content with other curricular areas

	Applied content to real-world situations
The implementation of big ideas	Encouraged input and challenged students' ideas Was non-judgmental of student opinions Solicited alternative explanations
Grasp morality behind chemistry	Got students to gain the ethical sensitivity and ethical judgement Helped students understand their ties to society and their responsibilities within it Exhibited pedagogical phronesis in his/her dealings with students

The analysis looked at how PCK and PB&V are used to teach chemistry. This was done to look at differences in chemistry classes in four different jurisdictions while the teachers were putting them into practice. PCK and lesson structure analysis were used to find out how the teachers performed their jobs. How they broke their lessons up into different parts, the order of the tasks for meaningful learning, how long they spent on each part, and how the students were involved in each part. For example, a teacher using more than one way to explain a concept, was coded as an instructional strategy. The classroom teaching was coded at different times and checked to see if the codes were the same each time. This helped me figure out how reliable and valid the coding was. By taking apart the form of coding stripes and analysis, I was able to compare teachers and the ways they teach in different countries using the same type of analysis. This assisted me in determining what great teaching looks like in practice. This also helped me in determining if the teachers' interviews corresponded to their practice. While analysing the classroom teaching and practical work of several teachers, a range of lesson structures were noticed. Figure 4.4 is an example of Se-lesson Hoon's structure in South Korea.

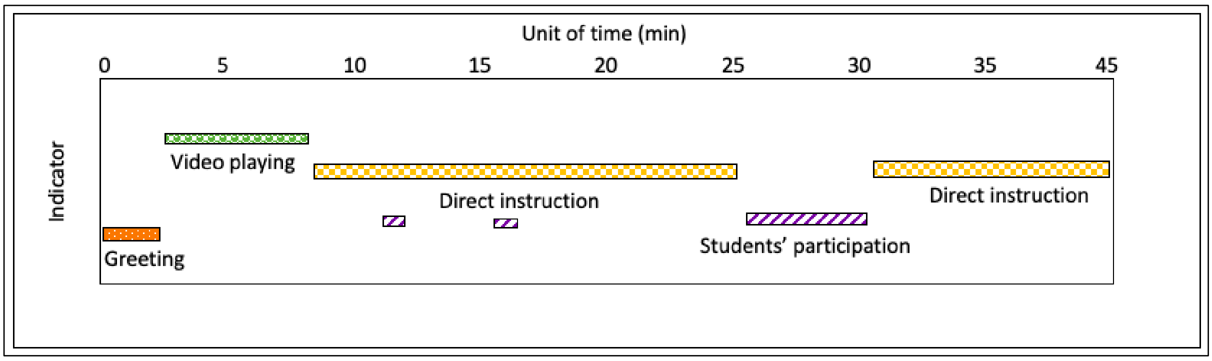


Figure 4. 4: Se-Hoon's classroom teaching structure

As seen in Figure 4.4, when a teacher employs multiple resources (models, drawings, graphs, and videos) to promote student comprehension, this is categorised as an instructional approach. When students reflected on and evaluated their own progress toward chemical understanding, this was coded as student participation. Direct instruction is coded when teacher-centred practice is used and a teacher provides knowledge.

4.11.5 Data analysis of the teachers' professional development activities

The dataset to address RQ2 and RQ3, PD activities were analysed. The analysis of the PD observation aims to investigate how teachers' professional knowledge is improved and refined through CoP. Therefore, my observation focused on elements of PCK proposed by Kind and Chan (2019) and components of CoP proposed by Wenger (1998). Based on Kind and Chan's (2019) synthesis of PCK, the Oregon Teacher Observation Protocol (OTOP) was implemented to analyse PD activities. The OTOP was also coupled with the final coding template. Ten items were identified. Each item was described in Table 4.13, which shows how to code them. See the transcript of PD activity observation in appendix 22.

Table 4. 13: A framework for identifying the various components of PD activities

Codes for different patterns in the PD activity	Features of the Patterns / Structures of the PD activity
Curriculum knowledge	Activities focused on developing teaching strategies associated with underpinning classroom context.
Shared repertoire	Teachers were provided with active learning opportunities related to a cognitive point of teaching chemistry.
Context-based chemistry	PD introduced new instructional strategies to do with meaningful connections between skills and ideas, and real-life situations
Educational materials	PD provided teachers with the organization of resources and materials, which aimed at students' cognitive development
Mutual engagement	Activities helped exchange information and expertise among teachers and others, e.g., academics, industrialists to realise students' preconceptions and misconceptions
Content knowledge	Activities promoted opportunities to update teachers' knowledge delivery of chemistry in light of recent advances through collaboration and job-embedded context.
Reflective practice	Teachers reflected and practiced variety of instructional strategies to represent concepts
Joint enterprise	Teachers were engaged in teaching tasks based on what students need related to societal issues
Practical wisdom	Teachers raised awareness regarding pedagogical reasoning along with the implementation of big ideas
Practical-moral knowledge	Activities enabled teachers to question the importance of moral and civic purpose of teaching chemistry.

As is the case with classroom observation, different sorts of structures were seen during PD activities in four countries. Figure 4.6 presents So- Heon's structure in PD in South Korea.

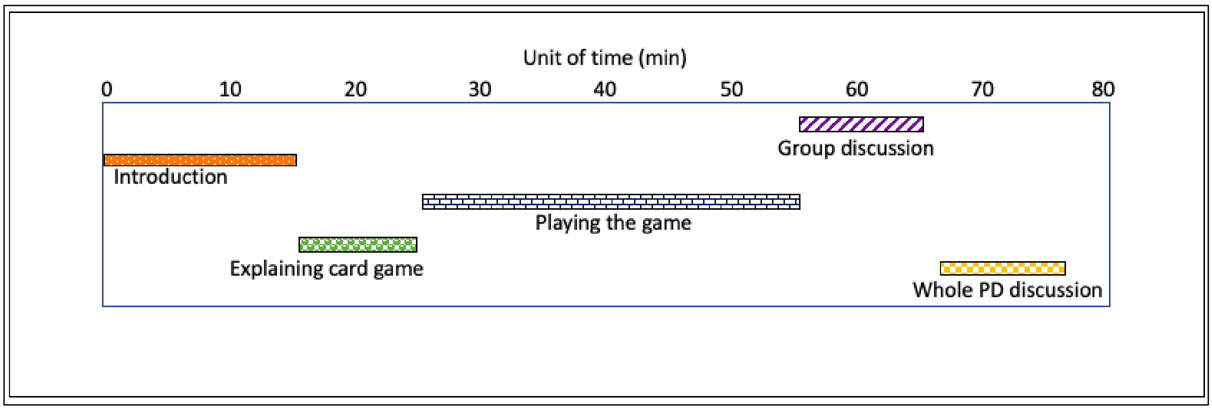


Figure 4. 5: So-Heon's PD session structure

As seen in Figure 4.5, when a teacher explained other teachers a new card game to teach topics better, this was coded as a new instructional strategy. When the presenter asked other teachers to discuss with their pairs as a form of social interaction, this was coded as pair discussion, and when teachers worked in small groups of three, four or five, this was coded as small-group discussion. When teachers brought together to obtain others' responses, this process was coded as a whole-class discussion.

4.12 Validation of the findings

Internal and external validity and reliability are associated with quantitative approaches. Nevertheless, validation of research should be considered in qualitative research (Guba, 1981). Reliability and validity are represented by trustworthiness and authenticity in the interpretivist paradigm and so refer to credibility, dependability, confirmability, and transferability (Golafshani, 2003). Four criteria of trustworthiness proposed by Lincoln and Guba (1985) were adopted in this research. To improve the data's trustworthiness, methods on how to code the data were described (as previously explained in section 4.11.3), including the template used in the coding process, a coding sample from the transcripts, and connections between codes and themes.

Thematic analysis is open to bias and subjectivity, which may lead the researcher to interpret findings incorrectly (McGloin, 2008). Hence, peer review (a colleague of mine) was adopted to check whether the findings of the study were grounded in the data produced or not (Krefting, 1991). All data was shared with my supervisor. The findings were also reviewed by my supervisor. Using a multimethod approach maintains overall credibility of research

(McGloin, 2008). Triangulation enhances credibility (Yin, 2018). I triangulated the data through collecting document information, observation, and focus group interviews.

Using a numerous case study technique, the aim of this case study was to add to the body of evidence. The research itself improved the study's coherence by using a multiple case study methodology (Krefting, 1991; Yin, 2018). Dependability is the ability of the data to remain consistent under comparable conditions (Cope, 2014). McGloin (2008) emphasised that an audit trail is suggested as a means of verifying the dependability of the data in order to guarantee trustworthy data collection. I think it was helpful to see and attend these even if the professional development and the courses I witnessed differed depending on the jurisdiction, as it showed how the instructors incorporated the idea of practical wisdom into their instruction.

Confirmability is linked with neutrality of findings (Guba, 1981). Case study research findings should be derived from the raw data, not the researchers' perspective and imagination (Krefting, 1991). Member checking was adopted to verify whether the participant's transcription matched his/her thoughts and opinions. I emailed their transcripts to all the participants from Turkey, South Korea, and Israel for checking.

As I investigated great teacher in different jurisdictions, my findings could be generalised to a certain extent. The detailed description of the research process also enhanced the applicability of the research to diverse contexts. I have provided sufficient information to others who can then transfer the research to other nations and the cases. Although the sample size of the study was small, purposeful sampling and working with experienced teachers combined with multiple data collection methods allowed me to generate rich data (Yin, 2018).

4.13 Summary

The approach that was used for this study was mentioned in this chapter. To analyse the concept of great teaching and how to cultivate great instructors in four different countries, a qualitative comparative case study methodology was chosen as the research strategy. There were a variety of approaches used, including conducting interviews, observing people in focus groups, and analysing documents. Both the participants and the locations of the investigation were chosen on purpose. This research enlisted the help of forty volunteer science educators who were instructing high school students ranging in age from 14 to 18 years old, had a minimum of five years of teaching experience, and participated in professional development activities in order to get a better understanding of their individual growth trajectories throughout the course of their careers. In order to gather information from educators, researchers travelled to both the Shingwaram in South Korea and the Weizmann Institute in Israel. The methodology for data analysis was also broken down and discussed. This chapter provided an explanation of the ethical difficulties that arise in the process of case study research. The data sets obtained from each of the four nations are presented in the next chapter.

Chapter 5: Reporting of the data sets and outcomes of data collection in four nations

"I do not blame the children for not learning; I would blame myself for not giving them the right opportunity to be able to achieve that."

-Elizabeth, Science teacher, England

5.1 Introduction

This chapter builds a foundation for answering RQ1 and RQ2. This chapter reviews all the data sets systematically to investigate how great teachers in science education are perceived in the four nations and how those teachers can be developed. This chapter introduces four themes that emerged from the deductive coding (i.e., community of practice (CoP), pedagogical content knowledge (PCK), and professional beliefs and virtues (PB&Vs)) identified in chapter 2 and 3 as well as the interviews and the other data sets through inductive coding (i.e., professional behaviour and behaviour management). Findings relating to how great teachers are perceived and developed as well as how practical wisdom influences teachers' practice are presented in the four subsequent subsections. Thus, the findings relating to the four nations (England, Israel, South Korea and Turkey) are then presented in section 5.2, 5.3, 5.4 and 5.5, respectively. These analyses show how the themes apply across the whole data set for each nation. In the concluding, section 5.6, I draw out differences between the nations.

5.2 Case 1: England (United Kingdom)

The semi-structured interviews (see Section 4.10.1) was designed to capture similarities and differences regarding perceptions of great teaching and great teacher among ten science (mostly chemistry) teachers of 14 to 18-year-old students in England. Based on thematic analysis, six distinct themes emerged. Each of these is discussed in turn. The next subsection discusses evidence relating to CoP from all the data.

5.2.1 Community of practice (CoP)

The semi-structured interviews with the teachers aimed to identify in what ways CoP experiences impact on their practice, enable them to update their knowledge of science, and promote the exchange of knowledge expertise between them. Previous studies pointed out that PD impacts on improving teachers' practice and in turn improves students' achievement and learning outcomes (Gore et al., 2017). Eliot in England highlighted how he updated his knowledge through the idea of CoP:

> I would say it always makes me be able to be a better teacher in terms of classroom management, behaviour management, when I attend PD. The RSC has a section where we chemistry teachers conference every year so when you go there you meet a lot of experienced teachers and share knowledge about topics that we are teaching. So, exchanging ideas makes me better teacher. I confidently say this makes me very good teacher (Eliot, February 2021).

This extract shows that Eliot's PD experience help him develop skills related to pedagogical knowledge (PK) (i.e., classroom management) through sharing and exchanging knowledge and ideas. Eliot's participation in PD allowed him to engage in knowledge sharing, which Wenger (1998) refers to as a shared repertoire. However, Eliot does not mention in what ways his practice is developed. When Eliot was asked in what ways PD has promoted exchange of knowledge expertise between teachers, he explained how his PCK was influenced by PD, as follows:

> We had the 'TeachMeet' community in West Yorkshire where chemistry teachers meet. So, in that case, we share our practice. So, in that case, like saying "this is what I am doing in the class to teach this particular topic" then people would be able to question him or her saying "why did you do like this? and why did not you do like that?" For example, I learned how to apply flipped learning successfully for my students and I learned how to explain some chemistry concepts using easy language for students (Eliot, February 2021).

The excerpt from Eliot indicates that coming together with colleagues who shared the same repertoire helped his to foster their practice and reflect back on why some topics require experimental work and why some topics require direct instructions. Reflective practice distinguishes the PD given by RSC from that of the 'TeachMeet' group. Eliot's PD experience in RSC and the 'TeachMeet' community include components of shared value and shared repertoire, but these two CoP features make sense when accompanied by reflective practice.

In this regard, PD should consist of a reflective nature where teachers critically engage to find the best way to deliver knowledge for students (Darling-Hammond, 2017). Differently, in her interview, Emma described how PD supported her development as a teacher:

> The most beneficial CPD I have done is through the 'ResearchEd' community and the series of events which they put on. The one which I attended last academic year at Durrington High school led me to reflect a lot on my own teaching and then implement new ideas such as dual coding which had been introduced at the conference (Emma, February 2021).

This excerpt indicates that the 'ResearchEd' community not only introduced Emma to new instructional strategies such as integration of coding into teaching biology, but also gave her an opportunity to reflect on her own teaching. She went on to explain her PD experience by saying

> I find the PD which is whole-school focused in school is sometimes not as beneficial. I think this is because each teacher has different CPD needs and targets and therefore a generic CPD programme does not benefit individual teachers as much (Emma, February 2021).

The two quotations above show that Emma has practical wisdom ability about what works for her practice, which leads her to find the best effective PD to attend. In England, research showed teachers tended to attend PD which is relevant to their teaching. Therefore, no subject-related PD at the secondary level is taught to contribute to teachers' practice (Wellcome Trust, 2006). Another chemistry teacher Emily gets benefits from PD, which supports not only her PCK, but also her PB&V. She explained how PD contributed to changes on her PB&V as follows:

> I have been joining the community where we analyse research-based articles, reports, and books. In that community there are experienced teachers and new qualified teachers (NQTs). If I am explaining mole calculation, some of the things that I assume that children know, but they do not know. I have just assumed they have known those topics. But now, I know that they do not know. In this reading club, we are looking at research-informed strategies. We are analysing together and learning together whether those articles fit into my class or not. Because of reading those articles with colleagues, I stopped making assumptions (Emily, February 2021).

This quotation from Emily indicates that such communities provide teachers with better insight by informing them about research-based strategies which end up with their reflecting on their teaching and making changes to their practice.

One of the most significant takeaways Emily received from the community was the recognition of students' knowledge. Kind and Chan (2019) emphasise the significance of KoS (knowing students' misconceptions and previous knowledge) by recognising it as a separate knowledge type in PCK. Second, review policy research conducted by Darling-Hammond et al. (2017) showed that one of the seven important features of effective PD is feedback and reflection.

“In effective PD programs, the practices of generating feedback and supporting reflection often include opportunities to share both positive and constructive reactions to authentic instances of teacher practice, such as lesson plans, demonstration lessons, or videos of instruction” (Darling-Hammond et al., 2017, p. 15).

In contrast to the research done by Jones, Gardner, Robertson, and Robert (2013), which found that community-based PDs were more useful to new teachers than experienced teachers, Emily's excerpt above shows that novice and experienced teachers contributed to each other's learning and practice. This finding was also supported by Erik. When he was asked about his PD experience, the following extract shows how Erik connected his PD to PCK and PB&V:

> So, I am supposed a little bit back to front now in the last 2-3 years because I have kind of become a teacher trainer. It is that providing training for other teachers I really feel help to me to become a better teacher in myself so the act of either being a mentor for PGCE students or NQT less experienced colleagues really help me kind of analyse what they are doing in the classroom and I kind of reflected on that when I think what I am doing in my classroom. Especially when I teach demonstration lessons for example, I would probably think a bit more carefully about what I am doing and why I am doing It. It kind of demonstrates the ideas those for trainee or less experience colleague (Erik, March 2021).

This passage demonstrates Erik's view of himself as a mentor who may have encouraged others and aided in self-reflection. Erik says that he can better understand his own teaching by serving as a mentor to others. This demonstrates that educators, regardless of their level of experience in the classroom, are accountable for the professional growth of one another when they have a common vision for teaching. The CoP was founded by Akerson et al. (2009) based on three science teachers who were supported in experimenting with novel approaches and reflecting on how they were incorporating the nature of science (NOS) into their teachings via frequent meetings at school. The study's conclusions demonstrated that making NOS a common objective inspired instructors to connect with one another more and develop better bonds. Teachers' professional development in England is primarily focused on shared repertoire, one of the components of CoP (Wenger, 1998). The passage that follows explains how Eva gains from professional development that supports her teaching methods for each and every student in the classroom.

> If you are thinking about a specific topic, or even a specific child, you might be talking about dyslexic children or children who have English as a second language. (…) You can really delve into how to support that child and get ideas. So, with that, I have not been very good at getting ideas for myself about those types of students. So it is important that things are delivered to you. So, for example, I have been on courses that talked about dyslexic children and, as I said before, children with English as an additional language. So, I would not know strategies myself, so it is good somebody else just tells me, "Okay, this is what you need to do with this child." Actually, when they give me specific ideas and explain why, for example, in remote learning using subtitles for our lessons for the students who have English as their second language, I would not realise it would be difficult for somebody to understand, and of course somebody told me maybe you should do that, actually giving specific ideas like that is very helpful (Eva, February 2021).

Eva highlights the importance of coming together with other colleagues who have a shared repertoire to develop new instructions for students with special needs. Her moral character of fairness and caring for all students in the class leads her to go the extra mile for her students and helps her develop new pedagogy and perspective to support students. Her comments show that community supports both her PK and professional beliefs and virtues. However, not all teachers need the same PD. Thus, teachers need to know what they need for their practice. Elena, for example, demonstrated wise decision-making when it comes to choosing PD. When she was asked ‘What PD experiences have you had that supports your work as a teacher?’, she said:

> I think different stages need different PD. At the beginning of my teaching, it was very much a case of behaviour management. And those courses (…) gave you strategies for managing classes. (…) Recently, I

> have got back into A level teaching. So I need PD courses which support my subject knowledge (SK) (Elena, February 2021).

The excerpt above indicates that teachers need various types of PD based on their needs. When Elena was a novice teacher, she attended courses relating to PK. Darling-Hammond et al.'s (2009) study in the United States about PD of USA teachers showed that although nearly all novice teachers attended PD in their beginning years, nearly half of them preferred to participate in PD relating to behaviour and classroom management. Teachers in England prefer to participate in PD focused on SK rather than in other types of PD (Higgins et al., 2015). Ethan believes that practical works can help foster students' intellectual virtues such as critical thinking and problem-solving. His beliefs also help him decide what kinds of PD he attends. When asked about what PD activities to attend, he said:

> Attending international science meetings such as the Science on Stage conference and attending those which focus on subject-specific [areas] provided by RSC and ASE are the most significant impact on my practice. You know in terms of practical workshops, I think if I know the best ways and more efficient ways to teach practical work, pupils engage more. I found quite useful subject-specific CPD for practical knowledge for PK, how students learn, how to assess them (Ethan, February 2021).

The quotation from Ethan indicates that he found practical work to be a way of engaging students in chemistry class. His beliefs may have influenced the way in which he delivered scientific knowledge. This excerpt also indicates that PD contributes to students' learning. He added reflection as an important dimension in delivering knowledge to students. Excerpts from Ethan and other teachers so far show that practical work should be supported by reflective practice, which helps teachers to be aware of their wise decision-making and pedagogical outcomes (Larrivee, 2000). Apart from subject-specific PD, some teachers either attended different types of PD or were responsible for their own PD. When asked 'Which PD have had the most significant impact on your practice as a teacher?', Emilee replied:

> I would definitely go with meta-cognition PD (…) because those gave more detailed insight into the psychology behind how students learn, how to present information in steps. You know… give them the ownership as you are the expert, and you are providing expertise to the novice and practice as well, so all the ideas, retrieval practice, and recall just to build confidence in the learners so they are no longer thinking ohh… this is so stressful and difficult, you know, giving them steps and skills that they can use and become more efficient learners (Emilee, February 2021).

The excerpt above indicates that Emilee couples instructional strategies with a psychological perspective on learning to provide students with a comfortable environment where students can develop their skills and become more efficient learners. Emily combines her PCK into character virtues to provide students with a stress-free learning environment. In this regard, attending PD promotes her practice and ability to achieve her goal. In contrast, Elizabeth is a self-motivated teacher. In the initial interview with her, she described her way of development:

> In terms of PD, that is all my PD, I do by myself in terms of I am really interested in research; I am really interested in thermodynamic, how to teach; I am really interested in misconceptions. I am interested in learning anything and students' achievement. I think I grew up as an individual because of my experiences working with great variety and a bicultural-mixed rather than multi-cultural society that we have in the UK. I think it was very useful for me to spend time abroad in terms of individual growth. That was the best PD that I could have. I developed significantly through my journey to New Zealand and that was the best PD that I have ever had because I became more digitally literate, and I also became more confident in my teaching (Elizabeth, February 2021).

The excerpt above shows that Elizabeth has objectives that she sets up to develop herself. That is why she thought that PD is not necessarily disseminated other that through the collaboration channel. Overall, the findings show that teachers develop their teaching practice throughout their attendance at PD. To some extent practicing the components of CoP is true for England. To some extent, PD provides an environment where teachers demonstrate reflective practice. However, PD in England contributes mainly to teachers' CK and PK.

The research examines how Communities of Practice (CoP) experiences affect teachers' practice and the development of exceptional teacher traits. Eliot's experience shows how CoPs strengthen classroom and behaviour management abilities in teachers. Eliot learns significant educational practices and insights at CoP-organized professional development (PD) sessions, emphasising the importance of PK in teaching.

Knowledge exchange and collaborative conversations in CoPs are crucial to their reflective character. CoPs encourage reflective practice, helping instructors like Emily evaluate their approaches and find the best ways to educate. Thus, pedagogical content knowledge (PCK) and character characteristics like justice and student care are needed to become a successful teacher.

Teachers like Emma, Elena, and Elizabeth demonstrate the value of teacher-driven PD. Their ability to choose PD that meets their needs and objectives shows practical insight. Emma and other great instructors prioritise professional development to reflect on their teaching approaches and benefit their pupils. The research shows how CoPs build exceptional teachers via shared knowledge, reflective practices, and PD that meets individual needs. These attributes include subject knowledge (SK), effective pedagogy, meeting students' needs, and a strong dedication to teaching excellence. The next section discusses how teachers in England think about PCK as a component of great teacher and teaching.

5.2.2 Pedagogical content knowledge (PCK)

The semi-structured interviews with teachers indicated that teachers' subject matter knowledge (SMK) or CK is one of the most important factors that influence their practices, instructions, and PCK. Previous studies have pointed out that SMK is significant for the development of PCK (Mahler, Großschedl, & Harms, 2017). "Misconception-free CK (or SMK, or other variant) is a prerequisite for devising or delivering instructional strategies that positively impact student learning abstract science concepts" (Kind, Park, & Chan, 2022, p. 328). In the interviews, teachers in England were asked what qualities make a teacher great. In the initial interview with Ethan who teaches A-level chemistry, he provided the following response:

> I think good SK is a starting point and I think good SK can control classroom behaviour and management. Excellent SK is needed to answer questions from the students but also to teach the content the best way possible (Ethan, February 2021).

The excerpt above indicates that Ethan considered that SK is a prerequisite for being an great teacher. He also linked CK with PCK. In line with Ethan, A-level chemistry teacher Eliot believed that

> Chemistry is the same everywhere and it is very easy to teach as a teacher, if you have a good SK. No matter how good a character you have, if your SK is not very good, you cannot be able to get students

engaged. Chemistry teachers should explain some chemistry concepts using easy language for students to able to understand the topics (Eliot, February 2021).

As these quotations show, good SK, especially when teaching A-level chemistry, physics, and biology, is essential to engage students with topics. However, possessing good SK is not enough to deliver knowledge effectively to students. Kind and Chan (2019) emphasised the importance of teachers creating learning environments for their students: without this, topic knowledge has little impact on learning. Explaining some abstract chemistry concepts or knowledge of common misconceptions in chemistry requires PK to facilitate learning and make it meaningful. In her initial interview, Elena explained:

> There is a big push in our school for 'cognitive learning'. It is a buzz word in our school nowadays. The push is not necessarily SK but more about how the students are learning. And using different strategies, Rosenshine's principles, so this is a big push in our schools and across the academy trust. It is not subject-specific, but it is quite long time ago, came up with these key pillars of learning something like seven strategies. It is more about PK how student learn (Elena, February 2021).

For example, in her initial interview Emilee highlighted the importance of modelling the kinds of strategies Emilee used when she taught bonding.

> You know, for example, Frayer model, you have a key word, and you think of the definition so normally with key words everyone goes Oh! this is a key word, you must use it. This is the definition and write the sentence. I like the Frayer model which I have been using in class particularly bonding, you know metallic bonding, how it is different from ionic bonding because you have got electrostatic force and both, you know, one is positive ions and another one is cat ions, so it is terminology like that and then you have example and nonexample which is what I have learnt from the Frayer model (Emilee, February 2021).

Similarly, in Ethan's initial interview, he said that demonstration in microscale in chemistry works well to explain abstract concepts.

> I have a keen interest in microscale chemistry, for example, microscale demo of how some ionic and covalent compounds can relate to properties such as melting point. I would also demonstrate for example using ring magnets to demonstrate differences in covalent and ionic bond formation. However, I make sure [students] really understand what the demonstration is about rather than just making fun (Ethan, February 2021).

The aforementioned passages demonstrate how Elena, Emilee, and Ethan present the subjects in different ways. Chemistry deals with abstract ideas like characteristics, electron and ion mobility, and material change. Teachers present new subjects using models to make the ideas of chemistry readily comprehensible. For instance, Rosenshine's principle of cognitive instructions urges educators to provide pupils with new ideas by modelling their own thinking (Rosenshine, 2010). The "Frayer model" fosters critical thinking in pupils and assists them in applying scientific literacy. In order to increase students' understanding of chemical ideas, using models is crucial (Gilbert & Treagust, 2009). Justi and Gilbert (2002) have noted that prior research has also shown that not all models are effective or that models might sometimes cause misunderstandings in students' comprehension of the subject. Teachers should thus consider what works and what doesn't. Practical wisdom, which was discussed in part 2.6 and recognised as an inductive subject in section 6.3.1, is necessary to do this.

5.2.3 Professional Beliefs and Virtues (PB&Vs)

The previous section provided evidence on PCK, as PCK is believed to have a direct influence on how to become a great teacher. This section provides evidence from the semi-structured interviews to explain how teachers' beliefs and virtues influence their decision making and practice in teaching chemistry. Nespor (1987) points out that teaching practice is framed by beliefs which tend to be shaped and changed through experience and context. Emma's practice is mainly influenced by her professional beliefs. In her initial interview, Emma said:

> I have passion for promoting different careers in science and for raising the students' aspirations through different clubs, trips, and residentials. From teaching A level biology, I make sure that the students have a recent news article focus where possible with links from our topic. Covid-19 has been a great opportunity to develop my SK when it comes to viruses and processes such as PCR which I teach in year 13 biology (Emma, February 2021).

This extract shows that Emma's passion helps relevance in her teaching. She supported students' learning by using up-to-date information. Emma embedded current issues into her teaching, which requires the combination of good CK and passion. For example, Emily's beliefs influence her instructions. When she was asked about her professional beliefs about teaching chemistry, Emily stated:

> I have been using modelling and Johnstone's triangle. I am trying to change my teaching practice and it helps to make class better. I am quite open to changes as long as they improve my practice. What I missed was, as I said before, I was thinking I was assuming that students have this knowledge at that time, but they did not have it. So, recognising this helps me to organise better instruction for my students (Emily, February 2021).

This quotation shows that Emily does not have fixed beliefs on teaching chemistry. She is open-minded to changing her practice based on what students need. Being open-minded to change is considered as an important intellectual virtue. Open-mindedness helps teachers gain a reflective character (Taylor, 2016). Similarly, Eliot is also an open-minded teacher who makes himself reflect on his practice. In his initial interview, Eliot reflected on himself saying:

> I believe that I can learn something from anybody, so I go to my colleagues' classroom to observe how they teach. And I want them to come over to my classroom and give me feedback. So I go to English class, French class. I also want my colleagues to observe my classes and I want them to tell me what I have done while teaching. I learn my mistakes. I am open-minded. I also do not fear to get feedback from my students. Sometimes, I handed out a survey to my students about how I teach (Eliot, February 2021).

The excerpt above shows that Eliot's open-mindedness on his teaching allows him to develop his teaching. His intellectual characteristic helps him in preparing a safe classroom for his students. Eliot narrated the incident below.

> One of my students told me, like that, Mr. Eliot when I come to your class, I believe that you've already prepared a safe class for me. What I meant, you allowed us to make a mistake. I know that if I make a mistake, you will correct it. So, this is one of my students shared his opinion. Students said when I finish teaching the topic and we do some activities and then if they do not understand, they just say we do not understand freely. That is why I said relationship comes first then SK (Eliot, February 2021).

The quotation indicates that professional knowledge of teachers plays a significant role in engaging students in a topic that the teacher teaches. However, preparing a classroom where the students and teacher reach mutual understanding allows students to ask questions and opens opportunities for meaningful learning. Apart from intellectual virtues, fairness, being accessible to all students, and providing reliable knowledge are considered as qualities that make teachers great. In the initial interview with Emily, she said she wanted to access every student in the classroom. She highlighted that she accesses not only students with intrinsic motivation towards science, but also students who are not motivated to study science:

> I think for me it is very important to make my lesson accessible to everyone. I think those are my key ideas, making sure everybody is engaged, I know where everybody is, where they are struggling. I want to create an atmosphere where everybody feels confident to ask questions (Emily, February 2021).

Teachers' beliefs is not static, it might also change based on what students need. When Elisa was asked, 'Do you have any changes on your professional beliefs about teaching chemistry?', she indicates the connection between her beliefs and teaching practice, as follows:

> I do not think my beliefs around teaching science have changed but I think teaching has made me more aware of the society where I live in the fact that this is going to make me more critical. But my belief is just that science is fundamental really to children. There are lots of useful life skills that come up with science you know being able to analyse, information and critique in which it is obviously very important skills. Children have access to so much information through social media and news and books they really need to be able to work out for themselves whether those claims are factual or whether they are fabricated. You know today for my year 10 students I have taught vaccination. You know it was very relevant back in 1998 when there was the MMR. So, MMR causes autism and then it turned out the vaccination rate dropped because people were scared of getting their children vaccinated (Elisa, February 2021).

The excerpt indicates that Elisa pays attention to developing her students' scientific literacy skills to make them aware of false information in the media. Students' future engagement with science is set by the PISA 2015 science framework. It says scientific literacy is the capacity for critical engagement with scientific questions and concepts. A person who has a good grasp of science and technology is receptive to debate based on evidence. (OECD, 2016). To be a reflective citizen, Elisa believes that students need to gain intellectual virtues through science. Great teachers can contribute to students' understanding of science through the cultivation of intellectual virtues such as critical thinking and analysing. Growing those character virtues helps students to identify misinformation in everyday life (Sharon & Baram-Tsabari, 2020). In line with Elisa, Erik and Emilee also think that chemistry should be relevant. Emilee makes chemistry relevant to make students aware of some societal issues. She said:

> I think understanding more and reading more around the subject, not necessarily reading chemistry books but just looking at things like economics, just getting involved things like climate change discussions, seeing how you know plastics in the ocean. You know people knew plastics would degrade but nobody has thought about what the long-term problem would be because they only thought okay just put it in landfills and the problem stops there, having this issue of mountains of plastics. You have got specific knowledge about chemistry, talk about it, say why you are interested in it, and how it links to the topics that you are

> doing. But also wider perspective, you might be a chemistry teacher but you have to link chemistry with biology (…) even some other subject geography economics. There are so many links where chemistry can be linked to something else. (…) (Emilee, February 2021).

This quotation from Emily shows that her beliefs about moral sensitivity and knowledge influence the ways she teaches her topics. She tries to make chemistry relevant and to link chemistry with other subjects and so helps to widen her students' perspective. Erik shows intellectual virtues while he delivers knowledge to students. He highlights his beliefs about teaching chemistry to his students as:

> Making science relevant to all people is a huge part of what I always tried to do as a teacher. if I look back on research projects that I have done myself over the time about teaching, a lot of it has been around practical work, in particular how I engage to students helps them get a handle on how we know what we know about science. I am asking a lot of questions, modelling ideas on the board, and getting them to think about why do we get these outcomes for this experiment. I will give them plenty of opportunities to consider there their thoughts in peer for example then they have opportunity to develop their thinking before we have feedback in the class. It could be best described as constructionist so I help them develop. I help them in constructing of the subject through dialogue and example and modelling concepts through demonstrations. In A level 16-18 I probably expect more from my students in terms of their ability to solve problems and construct explanations because you know they had 5 years of secondary education; they will know hopefully a lot of the basic concepts and expecting more them to bring ideas together from different parts of their understanding certainly at Key Stage 3. It would be like here are some chemical ideas here are some demonstrations what they look like in the real world here is the practical here is the question. So, I have greater expectation on the more senior students in terms of bringing ideas together. Therefore, probably, by the end of the chemistry course at the end of the GCSE, the all students have a reasonable understanding of the big ideas about science and then they critically engage with the world of science, like what we say about media topics which are discussed scientifically; they have ability to not just take everything and critically engage and ask questions, to get a good proportion of my students to want to do A-level (Erik, March 2021).

This excerpt from Erik shows that he wants to raise scientifically literate students who critically engage with the socio-scientific issues around them. Erik in his class seeks to create an environment and provide opportunities where students may practice virtuous characters. His constructivist approach to teaching provides his students with ways to understand big ideas about science. As opposed to Erik, Eva prefers to teach through direct instruction. Her

PB&V also influences her practice. When she was asked about her beliefs about teaching chemistry, Eva said:

> I do experiments, not all the time, but most lessons. I am very clear on my instructions so I show them in front of the class how to do the experiment. I also talk about what should they be expecting, name a piece of equipment, like. some teachers do the experiment and explain theory after, but I do it the other way around. I always teach them a theory and then we do the experiment to prove it. I think it helps because if they do not understand what they are doing, what they are expecting to see, I encourage them to question why is that happening, and then I go around, and say why are you doing that, what is the reason, can you explain what is that; important questioning and giving them confidence really helps (Eva, February, 2021).

The above excerpt indicates Eva uses didactic teaching strategy because she believes topics or experiments should be taught beforehand to make sense of the theory. Then she wants her students to ask questions about topics. Eva's teaching style is influenced by her professional beliefs and self-efficacy.

5.2.4 Professional behaviour and behaviour management

This section provides evidence from the data sets about how teachers' professional behaviour and behaviour management in the classroom influence their practice and help effective teaching. The quotation below from Elena indicates one further quality of a great teacher:

> To be able to leave your emotions outside the classroom. No matter what happens in the classroom, you always should be calm. For me, I am very happy person I'm always be like that. Students know what to expect with you. Very emotional one day and not the next and very enthusiastic one day and not the next so it is too much for the students. Always being the same person having rules, very fair, being encouraging, the right amount of encouragement not overdoing it which kids do not believe (Elena, February 2021).

As indicated in the quotation from Elena, behaviour management influences interaction between teachers and students. Professional behaviour management builds a positive classroom culture. In line with the above quotation, Ethan said:

> You know what, I have seen some teachers who are very didactive and very charismatic and hold the pupils' attention easily in 10-15 minutes and also some teachers they are not particularly charismatic but they are good at setting booklets and group works (Ethan, February 2021).

The excerpts from semi-structured interviews showed that behaviour management plays an important role in creating a safe classroom where students engage in class without hesitation.

5.2.5 Conceptualisations of great teachers

Previous sections addressed themes that emerged from the data sets. There, possible factors such as PCK, character strengths, and professional behaviour were discussed in determining whether a teacher is great or not. Although those factors were perceived as common components of being a great teacher, each nation placed different emphases on those components. Thus, each nation described great teaching differently.

The findings from the semi-structured interviews with teachers in England showed that self-reflection featured as a possible factor determining whether a teacher is a great or not. Experience of teaching is necessary, but this plus reflection on experience is needed to enhance practical wisdom, which plays a role in insightful decision-making and judgement. Elizabet stated:

> I fundamentally believe that a newly qualified teacher can be a better teacher than somebody has got 25 years' experience. I also believe that somebody who has got 25 years' experience is still a great teacher because he still has got the passion and still has got the reflective nature, so I do not think it is a liner process. However, to be great you have to be reflective. You have to be willing to make change on what you have reflected on. That is the simplest. Recognise the need for the change and frame it (Elizabeth, February 2021).

OECD 2018 report paid attention to ensure that students are equipped with the knowledge and abilities they will need to thrive in life and career, teachers are charged with continually innovating, adapting, and developing their teaching practices. (OECD, 2018). The excerpt from Elizabeth indicated that great teaching requires reflection, being responsive to the changes resulting from reflection, and reflecting on the needs of students because teaching is not the same as it was 20 years ago. In the interview with Ethan, I asked him how his beliefs had developed and changed throughout his time working as a teacher. Ethan said:

> I am a bit more critical about new things and instructions before trying them. When I started teaching, I was doing new sorts of things like cooperative learning, doing fun activities. But these days, if I am going to do fun and practical activities, I critically think whether it's worth doing it. Because, you know, to give

> an example; you know, the elephant toothpaste experiment, so when I do the demonstration, I make sure students really understand what the demonstration is about rather than just making fun (Ethan, February 2021).

Although Ethan knows many ways to instruct, he does not use them unthinkingly. Instead, he reflects on whether practical activities contribute to students' understanding of science. Although some experiments are fun, grasping how those experiments contribute to students' understanding is much more important. Emily is another teacher who thinks reflectiveness is an important quality which makes a teacher great. Emily commented:

> If one thing works for one class, it does not necessarily mean it will work for the other classes. I think a great teacher should be reflective; they should be aware of their classes, what kind of support they should provide class. They would be very good at assessing what students are thinking or what they are understanding what the gaps are, everybody feels safe and confident in the classroom (Emily, February 2021).

Emma supported Emily's statement when she said:

> I would say with certain topics I am an excellent teacher and with other topics I definitely am on the journey to excellence. This is mainly due to my SK and hence delivery of the curriculum. I believe it is important to be a consistently good teacher rather than a 'sometimes excellent' teacher, as this is better for the kids. Reflection is a key part in the journey to excellence (Emma, February 2021).

Both quotations from Emily and Emma highlighted that teachers have different classes and different topics to teach throughout the year. Each class and topic required reflection with regard to how to deliver knowledge and what kind of strategies should be used, what is useful for students, and which activities contribute better to students' understanding of science. In the extract below, Eliot gives an example of what he is doing in his classroom:

> If [the] topic requires practical work, I have integrated practical instructions so I can show them a diagram or something to reduce their cognitive load. But during the online class, I did not have an opportunity to do practical work. Instead, I used flipped learning, I used modelling and direct instruction a lot. When they do understand the topic, then I give them responsibility to go on exploring the topic in depth (Eliot, February 2021).

Teachers in England described a great teacher as someone who is constantly reflecting on what s/he is doing. This description suggests that reflection is part of a teacher's journey to becoming great teacher. Being reflective enables teachers to think carefully about 'what students need' and 'what works best for them'. Reflective teachers think about what works best for their students and decide what kinds of teaching activities fit best for their students so that they are able to understand the topics properly. Hence, reflectiveness is central to deciding the best instructions to use in the classroom. As noted by Loughran teachers' professional knowledge is influenced by their reflective practice. This reflection helps them to frame their instructions and develop their practice (Loughran, 2002).

Overall, the findings for each teacher in England indicate that great teacher was associated with being a reflective practitioner. The majority of teachers highlighted the idea that reflection plays a significant role in determining what kinds of instructions teachers utilise in practice. Some teachers used didactic teaching strategies. Some teachers used practical work. Some teachers preferred to use student-centred instructions such as flipped learning. Although they used many instructions to teach chemistry, the majority of the teachers in England agreed that being reflective is essential to be a great teacher. Teachers are able to build a bridge between their knowledge base for teaching and the ways in which that information assists them in preparing genuine classrooms by engaging in reflective practice. The results presented in section 6.3.1.1 reveal that reflection, coupled with autonomous judgement and the capacity to make judicious decisions, is what enables teachers to obtain the skill of practical wisdom, which in turn helps teachers become aware of what works and what does not work when it comes to teaching a subject in their environment. Some teachers for example Erik, Elizabeth, Ethan, and Emilee use a constructivist approach in their teaching, which supports students' conceptual development, connects socio-scientific issues into scientific culture, and engages them in meaningful learning. Thus, students taught by great teachers tend to reflect critically on societal issues and to show moral sensitivity. The findings reported in sections 5.2.1, 6.3.1 and 6.3.2 also show that communities, to some extent, provide teachers with an opportunity to reflect on their practice.

5.2.6 Teachers' professional development in context

The previous section explained how evidence from the data sets supported the deductive and inductive themes. This section addresses how those themes apply across England to identify teachers' PD. The following section discusses the data for England. In the semi-structured interview with Erik, when I asked him which PD has the most significant impact on his practice as a teacher, he highlighted how he developed his knowledge of A-level physics.

> I think it is not chemistry, but it was a PD in physics that I did. It was a SKE for enhancing my A-level physics CK. My degree was chemistry and my doctorate is in biochemistry. I trained as a teacher through the PGCE route. For the last couple of years, I have been teaching A-level physics. I was rusty in teaching physics. So, I attended a 2-day SKE course once a week for 6 months before I started to teach physics. That was very good being there [in that] room with teachers and experts and developers; that made a significant impact on what I did in the classroom (Erik, March 2021).

Erik's first degree was in chemistry, followed by a master's degree and doctorate in biochemistry. He has expertise in chemistry. When he started to teach physics, he attended a SKE course which provided SK to teachers who want to teach outside of their specialism or those who want to improve their SK. A shortage of specialist teachers (Weale, 2015; Morse, 2016), especially those qualified in science subjects (Stets, Brenner, Burke, & Serpe, 2016), is a reality in the UK. To address this shortage the UK government initiated SKE courses. These courses are aimed at training trainee teachers in terms of SK if they feel that they have a lack of SK (Woolhouse & Cochrane, 2014). Apart from SKE courses, teachers in the UK attended PD provided from different PD suppliers. Ethan for example attended subject-specific PD

> I am a member of The Association for Science Education (ASE). I have always attended PD provided by the ASE. Those were practical-based workshops about misconceptions in chemistry, teaching techniques, cognitive learning. I try to update myself by attending those workshops. I do not find attending more general PD useful and those which are not relating to science. I found quite useful subject specific PD for practical knowledge, PK, how students learn, how to assess them (Ethan, February 2021).

Eva was asked the same question as Erik. She has been teaching chemistry for about 10 years. She found attending PD provided by the Royal Society of Chemistry (RSC) quite beneficial.

> I supposed that the RSC one was the most significant impact on my practice. The one that is subject specific was really good because that kind of PD makes sense as you talk about your subject. It means we can talk about specific issues relating to chemistry (Eva, February 2021).

Elena responded to the same question as follows:

> I think the most significant impact on my practice was once where we were with groups of teachers in the same field, all science teachers, once we were able to talk about our experiences and hear others and get

> ideas from them. We belong to a United Learning Academy in an Academy Trust. So, there are lots of schools. We all got together in a big school and all the different science departments; we were all there together and we would be given an opportunity to talk through with each other to find what works in their school and we can talk about our school. Sharing ideas and knowledge, so that really helps (Elena, February 2021).

The excerpt from Elena indicated that the educational landscape in the UK changed when multiacademy trusts came into being (see Section 3.4.4 which discusses academy trusts in detail). Unlike Elena, Erik criticised multiacademy trusts saying:

> There would be very successful ones in terms of lots of schools as part of the trusts and therefore lots of opportunities for colleagues to come together from different schools and share their ideas and practice. The flip side is that some Trusts very much go down a cooperate model of education where resources and curriculum are dictated from the centre and all schools within that Trusts are expected to deliver education, rather than it feels like teachers become technicians almost delivering the education which has sort of been passed down from higher up (Erik, March 2021).

Some teachers in the study also highlighted that social media is a good platform where teachers connect with each other. During the Covid-19 pandemic, teachers in England highlighted ways to use Twitter effectively. Emma, Eva, and Emilee highlighted the importance of using social media. They said, respectively:

> I use Twitter for educational purposes and find connecting with other teaching professionals on there. It is hugely beneficial (Emma, February 2021).

> I do not know it counts but on Twitter I am very active. Lots of things on Twitter groups. For example, once a week I am part of group called 'chat chemistry'. I post ideas and people talk about it. I am a black lady so I am also organising workshops and seminars through Twitter relating to black teachers and issues (Eva, February 2021).

> I think what I have noticed about my personal knowledge of chemistry is finding articles from social media particularly Twitter because people are sharing ideas there is the Cognitive Science Society (CogSci) group. People are also sharing the stories about science. I think that is more useful because you know I knew the theory but how those theories have been developed (Emilee, February 2021).

Additionally, some teachers in the study found alternative ways to develop themselves. Take Elisa for example; she found courses based on what she needs. This initiative showed that she has a passion and love for learning and teaching.

> I found there is a school [called] McGraw Hill down in London. They are very successful. They have a similar intake to the school that I teach in. There are lots of disadvantaged students who qualify for free school meals but the school has fantastic outcomes. The school puts on PD sessions online and I watch as much as I can because I feel like they offer more tangible things that can be put into practice. You know, I studied biomedical sciences in university so my subject specialism is biology and chemistry therefore my physics is weaker. I did well in physics at school but I have not studied physics after I had left school so I watched some PD from a head of science from another school in Norwich. I watched PD, how he delivers explanations about energy and in that PD I was able to observe the pictures and diagrams he would draw as explanation that he would go along with delivering about energy so that really helps my SK (Elisa, February 2021).

Emily mentioned another type of PD, which in her view every teacher should take part in.

> At the present I am doing a PD course. That PD is all about looking at research in education. I think it is the best PD so far. It has been a really good experience to do the Chartered Teacher (CTeach); we are looking at research-informed strategies. I came across lots of books and articles about education which I did not do during my PGCE. So, I think this is the gap. Now I am closing the gap through CTeach (Emily, February 2021).

The results of the semi-structured interview with English teachers revealed that, in general, instructors favoured subject-specific professional development over overall professional development courses. Teachers who are required to instruct pupils at the advanced level in chemistry, biology, and physics are motivated to broaden their subject knowledge and seek out opportunities to network with other educators who share their areas of specialisation. As a result of this requirement, instructors are more likely to attend professional development opportunities that are subject-specific as opposed to those that equip them with professional knowledge. The professional development opportunities available to teachers in England range from whole-school PD to professional organisations to the professional development offered by multiacademy trusts, as well as online and individual initiatives (see Figure 5.1).

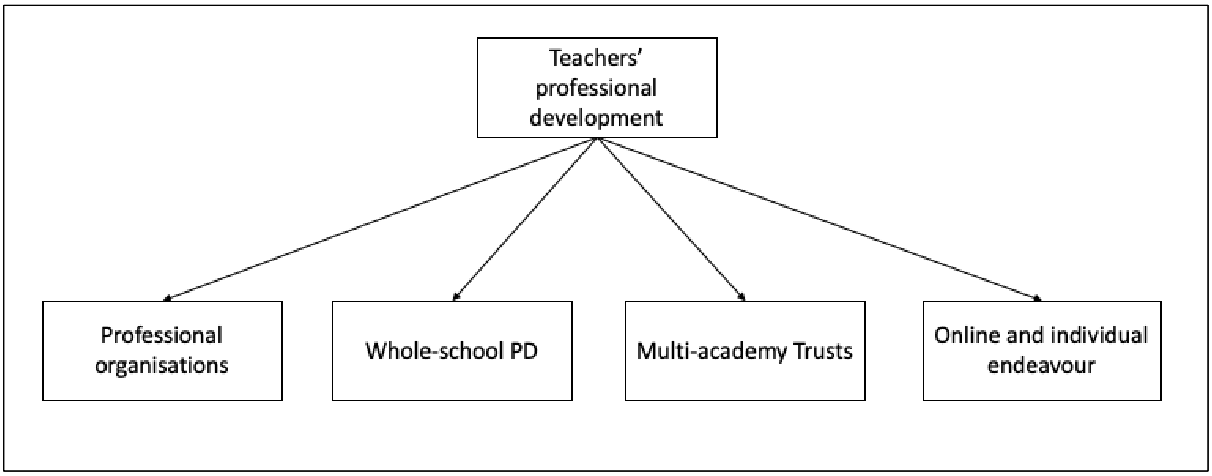


Figure 5. 1: Professional development provisions in England

5.3 Case 2: Israel

The semi-structured interviews (see Section 4.10.1), classroom observations (see Section 4.10.2), and observations in PD (see Section 4.10.3) were designed to capture similarities and differences regarding perceptions of great teacher and teaching among chemistry teachers of 14 to 18-year-old students in Israel. Based on thematic analysis, six distinct themes emerged. Each of these is discussed in turn. The next subsection discusses evidence relating to CoP from all the data.

5.3.1 Community of practice (CoP)

The substantial influence of community-based professional development (PD) on teachers' Pedagogical Content Knowledge (PCK) and Professional Beliefs and Virtues (PB&Vs) has been highlighted by the study's literature research and document analysis. The aforementioned data, as expounded upon in Chapters 2 and 3, highlights the significant role these elements have in moulding the attributes of an exceptional educator. A large amount of research, according to Vescio et al. (2008), suggests that successful Communities of Practice (CoP) are essential for improving classroom teaching and, in turn, student learning outcomes.

The research explores the contributions of those who may not have leadership positions within the CoP as well as teacher leaders like Ilana, Ivana, Idit, and Irit. With her twenty-five years of chemistry teaching expertise, Ilana is a leading teacher in her area and is tasked with helping less seasoned and inexperienced instructors facilitate CoPs. She also routinely attends meetings of a professional group designed especially for leader teachers, where she actively engages in the sharing of ideas and approaches. Ilana emphasises in her interview how her involvement with CoP has had a revolutionary impact on her development as a superb teacher. As seen in Figure 5.2, CoP has greatly impacted her professional values, moulded her PCK, and helped her develop the attributes that set a great teacher apart. As a leader teacher, Ilana demonstrates her dedication to professional development of both herself and her colleagues, which in turn fosters a collaborative learning environment that supports the professional growth of all participants in the Community of Practice.

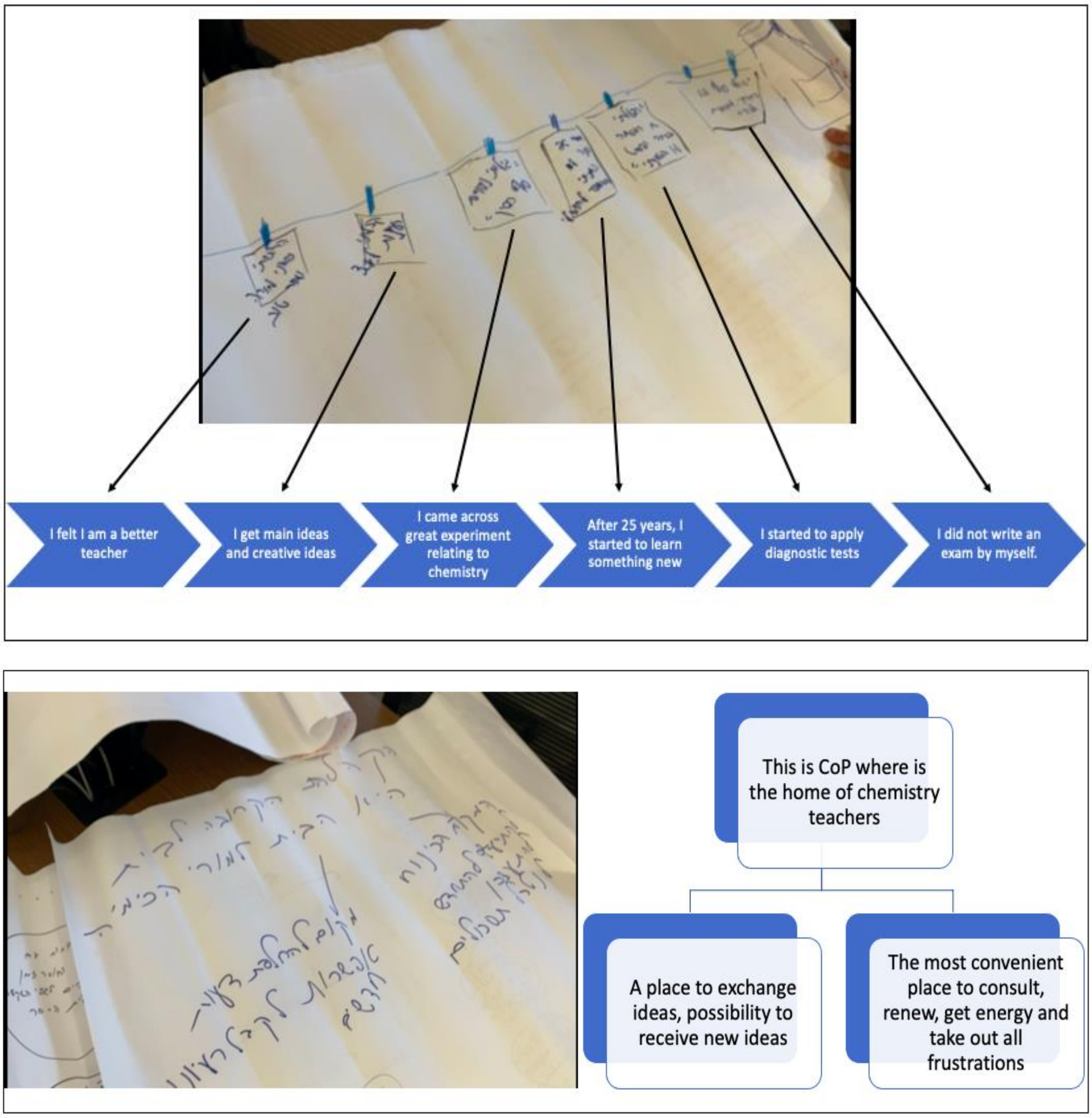


Figure 5. 2: Ilana’s perspective on CoP and her development to be a better teacher

She explains that when she started to attend CoP, she felt she was becoming a better teacher because she got creative ideas from other colleagues and learned instructional strategies which she had never applied to her class before. She indicates that CoP shapes her PCK and PB&Vs and vice versa. When she was asked 'In what ways has the PD enabled you to update your knowledge of chemistry?', she replied:

> Let's think you teach particles to students at 11-14. In a community, someone has a good idea he shared in the community and talked about it. Then you take it, then you apply it to your class. Then you can see students go 'wow I understood the subject'. They are very into it. For example, you can send students to the backyard and want them to collect materials. Then we can talk about atoms, molecules, and ions. This is one idea that came from a teacher in the community. They share their experience. They give a pedagogic point of view that you did not think of before. Take it, then adjust it to your school. If it keeps going, you can do something better. It is just an anecdote. We also do experiments in the community as well. Then take it to class. You can prepare in your class and show students. You feel much more confident in front of students because you have already done that experiment before and you have already known the result (Ilana, January 2020).

The excerpt above indicates that the CoP that Ilana participates in provides teachers with opportunities to build on their own instruction through sharing, collaboration, and reflective practice. Ivana is an Arabic-Muslim chemistry teacher in Israel. She is a leader teacher with 23 years' experience in teaching chemistry in both middle and high schools. Ivana also has taken advantages from community-based PD and contributed to the Arab cultural sector. She mainly participates in two community-based PD: one is the leader teachers' community at the Weitzman Institute of Science Teaching and the other is community-based PD for Arab teachers in a small Arab town. When she was asked in what ways PD has enabled her to update her knowledge of chemistry, Ivana responded as follows:

> If I lack something, I try to get help from the members of the community. Every member of the community also attends more different and additional courses than I do. Some of them attend technological courses, CK courses, general education courses, pedagogical courses. So, all of them bring the contexts that they have learnt from different courses to the community. And they share with us. We have lots of points of view in a single community (Ivana, January 2020).

The excerpt from Ivana indicates communities enable teachers to bring their ideas and to discuss those ideas together. This is the way she gains knowledge through community-based

PD. She also helped to develop other teachers in her community. The excerpt below indicates how she helps:

> One technological course deals with how to use scientific videos in the class. So, one member of the community that is very engaged with and interested in technological tools explained to us how to use videos effectively in the class. It was very useful for me. When I went to the small Arabic community, which I lead, I shared that knowledge with others and also my school (Ivana, January 2020).

Idit is another leader teacher who participated in the study. She has attended lots of PD, developed some projects like escape room and was part of projects such as Teaching Enquiry with Mysteries Incorporated (TEMI) and Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science (PROFILES). Idit explained how Israeli education and she herself gets benefits from the TEMI project:

> The Weizmann TEMI team including me is deeply involved in the Israeli National Centre for Chemistry Teachers, which is situated at the Department of Science Teaching at the Weizmann Institute of Science. To some extent, the numerous activities and methodologies developed in the framework of the TEMI project have become well known among teachers and teacher trainers across Israel. These activities and methodologies will continue to be taught in the framework of teacher training and teacher PD programmes. For instance, in the next school year several TEMI mysteries will be included in a year-long workshop for chemistry teachers – “The Chemistry Laboratory in High School”. Another fruitful initiative is the cooperation with the Carasso Science Park in Be’er Sheva. Usually, science museums do not have many chemistry exhibits, since they need perishable materials. The idea of this initiative is to introduce chemistry in the museum through TEMI activities. The rationale behind the TEMI project is that teachers are really performers in their class. If you are a performer, you should learn a little more about the skills of showmanship. You can teach the same subject with the same knowledge and materials but in a more interesting way. I think storytelling is a good way to teach chemistry. I would say TEMI makes very big changes in my class. I really like to do demonstrations and different activities which get students involved, but TEMI taught me a lot of performing skills. I am just thinking how to tell a better story like if you want to explain about atoms, then you can tell a story (Idit, January 2020).

The excerpt above indicates that attending TEMI PD contributed to Idit’s instructional strategies and influenced her professional beliefs on teaching chemistry. She found storytelling offered an interesting way to teach chemistry in a more enjoyable way. Idit was willing to implement strategies that she learned from TEMI PD. The project also encouraged her to teach chemistry in informal places like museums. This project also inspires other teachers in Israel. PD not only provides teachers with an environment where they can learn something new and create high-quality instructions, but also broadens teachers' imagination and impacts on their practice. The leader teacher programme that she has been attending also helped Idit to gain reflexivity.

Irit is a leader teacher with over 35 years' teaching experience in chemistry. As Idit does, Irit has also attended PD and PD for other teachers. When she was interviewed, she mentioned a PD which changed her career positively. This is how she explained how the PD impacted on her beliefs on science teaching:

> I think the PD that I took here at the Weizmann Institute of Science changed my career. It was a PD about leadership in teaching. It was a 2-year course, once a week in the morning from 9 am to 4 pm. It was an excellent PD. (…) What made this course special was the people, the leader of the course and the opportunity and go back to class and apply what we did in the course. It was not a summer course or something. It was in the week day and next day I applied it in the class. It is the most important because if you do something by yourself, it is yours. If not, it is still in your mind but it is not yours. If I recommend something about PD, first of all it should be a long-lasting not short-period and have the ability to plan activities followed by application in the classroom then come back to PD and then reflect to the others about what you have done (Irit, January 2020).

A reform movement in Israel which was previously explained in Chapter 3 aimed to increase the number of leader teachers through what were termed 'New Horizon' and 'Courage to Change'. The motivation behind the intervention was to produce more leader teachers who help novice teachers to become great teachers. Irit is a leader teacher who not only reflects on her teaching practice, but also takes advantage from PD which supports her intellectual virtues. What she highlighted as the most important element was the long-lasting nature of PD. Research shows that the duration of PD is a factor which impacts on students' achievement. Yoon et al. (2007) showed that attending a PD continuously (for 2.5–100 hours a month) helps teachers develop their instruction and knowledge, which in turn impact on students' learning. Another point that she raised is the reflective nature of PD and its applicability in the classroom. PD should give teachers the opportunity to reflect on what they have done. The extract shows that Irit connects her PD with improving her PCK and PB&V in her teaching practice. When Inbar was asked which PD has had the most significant impact on her practice as a teacher, she explained:

> Communities are the most significant impact on my teaching because first it does not focus on one particular subject or topics; we can talk about everything in community. It is not restricted to one thing. We do lots of things that I can use to develop my teaching in many ways. Second, it is very important for me because in Israel on average having one or two chemistry teachers in school so common a situation … you do not have another chemistry teacher in your school to talk about your problems with and to ask questions, so I came to this learning community 4 years ago and there are other teachers in the community who have the same problems as I have. We talked about solutions together (Inbar, January 2020).

The shortage of teachers to teach chemistry at the same school makes Inbar attend community-based PD because the community gives her opportunities to figure out problems that she comes across in her school. When she was asked how the community-based PD prompted exchange of knowledge expertise between teachers, Inbar explained:

> In learning communities what we mostly do is that we share activities that we do in the class. As the one leading the community, I bring the subject that we are going to talk about, and then we make a discussion in the community and lots of teachers share their experiences, how to deal with those problems in the classroom, what activities they do, how they teach it. We share; that is what we do most of the time. In addition, what I have learnt from the communities is how to prepare diagnostic questionnaires and then I used and I saw that students made mistakes and we have those sorts of diagnostic tests for each chemistry topic. It helped me because it identifies which kinds of mistakes they make and how can I handle them (Inbar, January 2020).

This quotation shows that the community-based PD contributes to Inbar's PCK and develops her reflexivity. What the above quotation indicates is that an enterprise is joint, not in the sense 'that everyone believes in the same thing or agrees with everything, but in that the joint enterprise is communally negotiated' (Wenger, 1998, p.78). Teachers who attend the same PD deal with situations as they reflect on situations and discuss them. All members of the PD contribute to knowledge to some extent. They share their experience with others to facilitate learning.

5.3.2 Pedagogical content knowledge (PCK)

In their interviews, some teachers highlighted that teachers should teach in various ways based on what students need. Irit from Israel, who has over 30 years' experience in teaching chemistry, said that

> Chemistry is an abstract subject, so you need to get help from videos on the Internet, using visualisation methods, movies, animations, and preparing PowerPoint presentations. The teacher needs to know many strategies for teaching. Teachers need to get students to be part of teaching, make them active in the classroom (Irit, January 2020).

This excerpt indicates that using technological tools effectively helps to engage students in class. The Covid-19 pandemic shows that teaching incorporates effective usage of multimedia and technology. Isaac from Israel highlighted that video recording the class not only helped him to reflect on what he had done in the class, but also gave him an opportunity to create an alternative learning environment where students could make choices.

> I noticed that after I started taking videos in my classes, I changed the ways I interacted with students. It becomes more theatrical, but I also need to be very careful, precise, and well-prepared because it is recorded. It makes me double check. I also came up with idea that if I make a mistake and a student of mine finds it, I give a bonus 5 points. Everybody is sitting in my class checking my class students got the grade and I got to fix those mistakes. That is awesome (Isaac, January 2020).

The excerpt shows that Isaac found out assessment which encouraged students to engage the class. The quotation below explains the qualities that Ivanka believes make a teacher great:

> I think for me CK comes first such as the basic understanding of reactions, mole calculations, acid-base and so on and so forth are important in terms of how to deliver them in a proper way. I think both PCK and CK are important. This is from the academic achievement point of view. Another point to do with what makes teacher great is to have good dialogue with students. These two qualities, knowledge and good dialogue, are essential to be a great teacher. Additionally, you understand that you need to move on further to master new techniques to study new material (Ivanka, January 2020).

The Oregon teacher observation protocol was used to analyse the classroom teaching based on Kind and Chan's (2019) PCK model. Classroom observation (see section 4.10.2) showed that, while teaching science, teachers made decisions in terms of the language they used in their instruction and the activity structures used to support students' understanding of science. The first classroom observation in Israel was conducted in Ilana's class where she explained density. Ilana's lesson structure is shown in Figure 5.3. She handed back the results of a quiz which had been done in the previous lesson. Students were given 5 minutes to look at the quiz. They were then asked some questions related to the quiz, followed by her delivering theoretical knowledge.

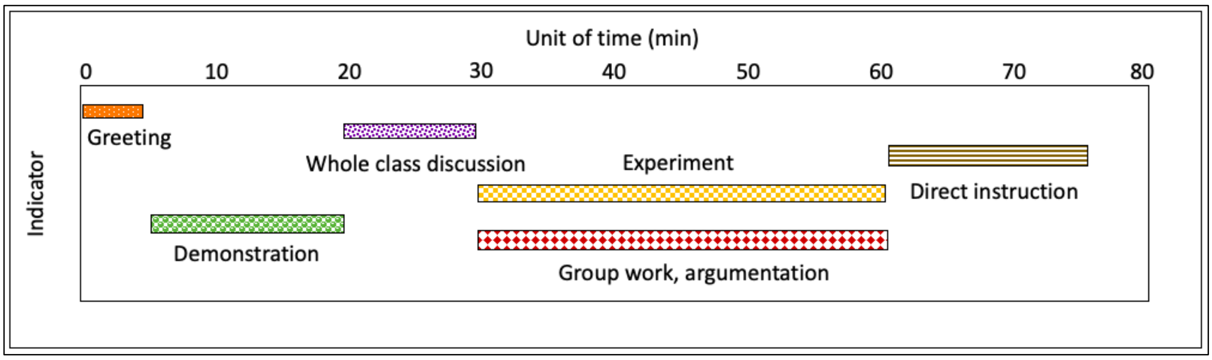


Figure 5. 3: Ilana's classroom teaching structure

Ilana used argumentation while explaining density. She engaged in dialogue with students, as shown below:

> **Ilana:** As you see, I have coke and diet coke. I did not open them. I have a tank of water here. I will put both at the same time. Let's see what is going to happen.
>
> **Ilana:** As you see, while normal coke sinks, diet coke floats. Why is that so?
>
> **Student:** It is about density. Normal coke contains sugar and diet coke does not, so diet coke sinks and normal coke floats.
>
> **Ilana:** Yes exactly. Both are exactly the same in terms of volume both 355 ml but one sinks and another does not.
>
> **Ilana:** Okay, now let's add another variable. If we tried the same activity with diet coke with caffein and diet coke without caffein, what would happen? Does the presence of caffein change the result?
>
> ……….

The excerpt from Ilana's lesson indicated that she prepared high-order questions for students to get them to think critically about density. She started with a demonstration to show the differences between coke with sugar and coke without sugar. Having provided the necessary CK for her students, she developed the activity to challenge students' understanding of density. She wanted students to apply argumentation while doing this sugar density experiment Figure 5.4.

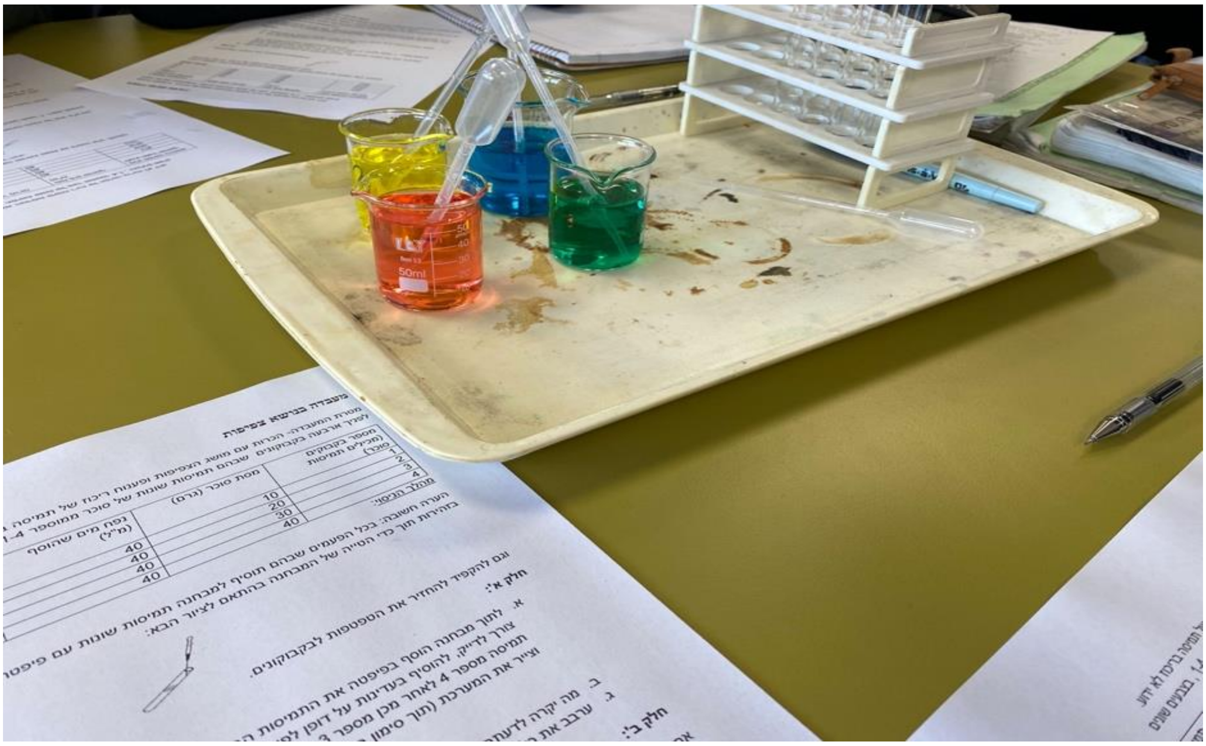


Figure 5. 4: Density experiment in Ilana’s class

Ilana demonstrated diverse instructional strategies such as demonstration, visualisation, and hands-on activities to scaffold students’ understanding of density. She did not give the whole information to her students. Instead, she wanted them to discuss the experiment in pairs and groups to find the answers. In line with Ilana, Ivanka, in her biology class, used direct instruction and argumentation while she was explaining DNA. Her lesson structure is shown in Figure 5.5.

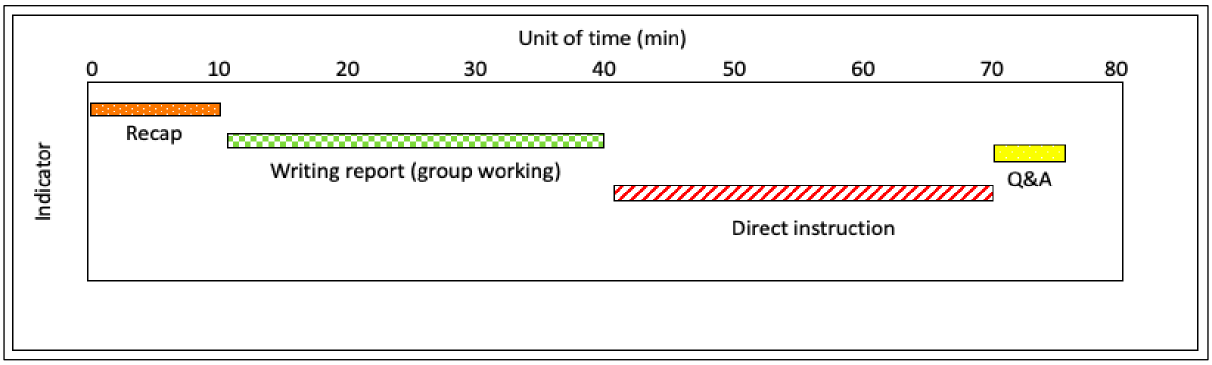


Figure 5. 5: Ivanka’s classroom teaching structure

She began with a recap of the previous lesson and then opened the PowerPoint presentation. The excerpt below shows how she conducted the recap.

Ivanka: Now, let's have a look at the board and try to remember together about what we have learnt to do with cell and organelles and their functions. Who is going to explain what is the organelle number three and its function? (see Figure 5.6)

Student 1: That is ribosomes. Regardless of cells, all cells like prokaryotic and eukaryotic have got ribosomes to produce proteins. Ribosomes are responsible for producing proteins from amino acids.

Ivanka: Yes, that is right. Additionally, ribosomes are in charge of assembling amino acid to form proteins that are essential to carry out cellular functions. The DNA produces mRNA by the process of DNA transcription. The mRNA is synthesised in the nucleus and transported to the cytoplasm for the process of protein synthesis. The ribosomal subunits in the cytoplasm are bound around mRNA polymers. The tRNA then synthesises proteins.

Ivanka: What about number 9 which looks like a slipper?

Student 1: That one is the mitochondria. The most well-known role of the mitochondria is the production of ATP, the energy currency of cells.

Student 2: Mitochondria are thought to play crucial roles in the maintenance of pluripotency, differentiation and reprogramming of induced pluripotent stem cells.

Ivanka: Well done. However, in recent years, a growing number of studies have demonstrated that mitochondria are also deeply involved in a range of other activities that enable cells to function efficiently and help to maintain a healthy body.

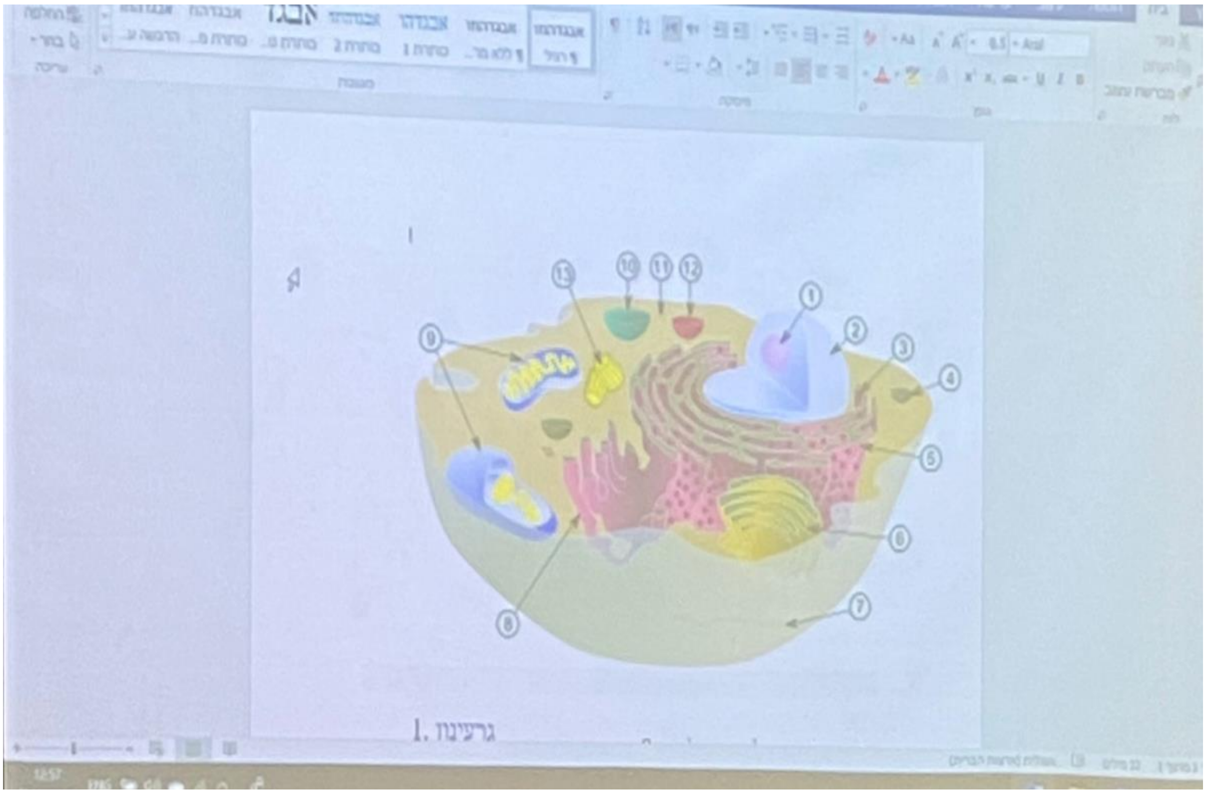


Figure 5. 6: Ivanka's presentation about cell and organelles

Ivanka retrieved knowledge from the previous lesson, which enabled students to grasp DNA better. After a 10-minute retrieval activity, she wanted them to complete a report. She wanted them to use argumentation to complete the experiment report.

> **Ivanka:** Now, I would like you to write down the report as a group in 30 minutes. Thereafter, I will start to teach about the DNA and then we will end today's lesson. When you have a look at the slides you will see what you need to do about writing the report. Just follow the order as it is written. If you have any questions, I will get there. Basically, what I would like you to do is to discuss with your group members about what you have done in the experiment for 10 minutes. The rest of 20 minutes you can complete your report. The reason why I want you to do this activity is to interpret the experiment and improve scientific language while discussing. So, let's move on and find your group mates quickly and start the report.

The students started to discuss the experiment. A reporter explained to the rest of group members what they needed to do. She explained:

> **Student 1:** The experiment was about the effect of the H_2O_2 on catalase. We have three stages before we finalise the report. First stage is getting acquainted with the phenomenon. In this stage we follow the instructions that were prepared by the teacher, raising accurate and correct scientific language, generating questions that include at least two levels of understanding (macroscopic, microscopic, and symbol…)

online research for relevant information for experiment. Second stage, using information collected from first stage we are designing the experiment. Designing an experiment that fits the RQ. Establishing of the hypothesis. And finally, we will write down the report.

Isaac tended to be more teacher-centred than Ilana and Ivanka. Isaac taught chemical equilibrium. There were lots of new terms which students were not familiar with. Therefore, Isaac explained those new terms and then solved questions. This was an examination class where students prepared for the Bagrut, which is a matriculation exam in Israel (see section 3.5). Isaac taught CK for the first 25 minutes, followed by solving five questions relating to chemical equilibrium in the last 20 minutes. Isaac's lesson structure is shown in Figure 5.7.

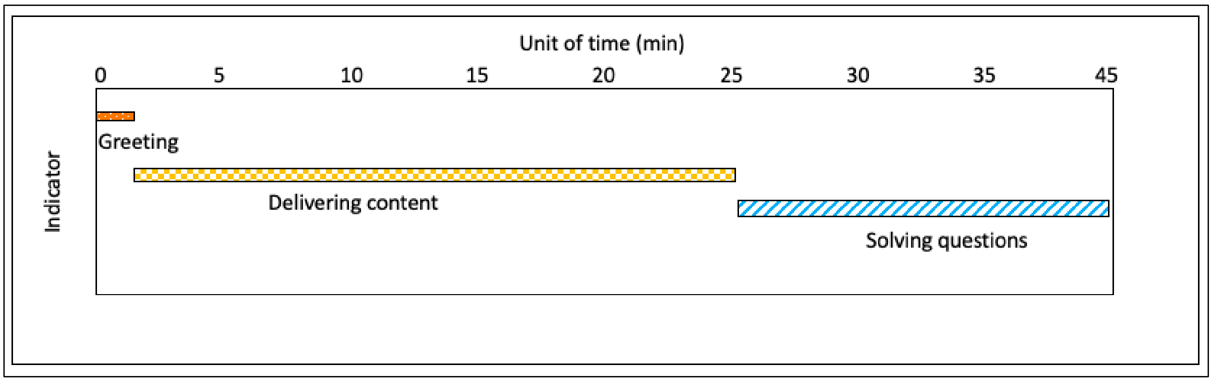


Figure 5. 7: Isaac's classroom teaching structure

In general, teachers who taught an examination class tended to choose didactic teaching instructions. They used less student-centred instructions. Chemical equilibrium in chemistry contains many conceptual difficulties that challenge students' minds. Van Driel et al. (1998) for example did an empirical study in the Netherlands to address students' conception on chemical equilibrium and promoted some teaching strategies for chemical equilibrium. When Isaac explained reversibility and irreversibility, he used different analogies.

Isaac: Now, I would like to let you know reversibility of chemical reactions. We are now on the third floor, right?

Students: Yes, we are

Isaac: I think there are three different ways to go down to the ground floor. First, I can use stairs, I can use the elevator, and I can jump from the window. So, when I jump from the window, can I come back to class again?

Student 1: I think you can but it takes a little bit longer. Probably you go to the hospital first

Isaac: ☺ Yes you are right. I think it is impossible to go back, right. What about when I use the stairs and elevator?

Students: Yes, you can come back to the classroom.

Isaac: Yes. So, therefore there are two kinds of reactions, which are reversible and irreversible. In reversible reaction, the reactants can convert to products and products can convert back to the reactants. Like when I use the stairs and elevator I can go back and forth. However, in irreversible reaction, it is impossible to produce the reactants from the products. Like when I jump onto the ground floor from the third floor…

This excerpt provides insight into Isaac's teaching style, which involves his deft use of metaphors and analogies to help his pupils understand difficult chemical concepts like equilibrium. His use of these illustrated strategies not only improves student understanding but also exemplifies what makes a good teacher. Outstanding educators, such as Isaac, have the ability to communicate difficult material in a unique and sympathetic way, making learning more approachable for their pupils.

Isaac's method also emphasises how crucial it is to provide pupils the necessary Content Knowledge (CK). He discusses basic ideas about chemical equilibrium, including Le Chatelier's principle, reversibility of reaction, equilibrium-dynamic balance, equilibrium constant, and equilibrium-affecting variables. Giving pupils the fundamental information they need is in line with the qualities of a great teacher, who works to provide their pupils a solid educational foundation.

Furthermore, Isaac's educational knowledge is seen in his preference for didactic instruction over experimental methods. He emphasises the flexibility and common sense that are necessary for a successful teacher, while acknowledging that the nature of the class and the subject matter may need a didactic approach. His videotaped reflection on his teaching methods shows a dedication to ongoing development and an acceptance of technology, both of which are in line with the changing needs of contemporary education. This excerpt essentially highlights how Isaac's methods of instruction exemplify traits of a good teacher, placing a focus on creativity, information sharing, flexibility, and a dedication to professional development.

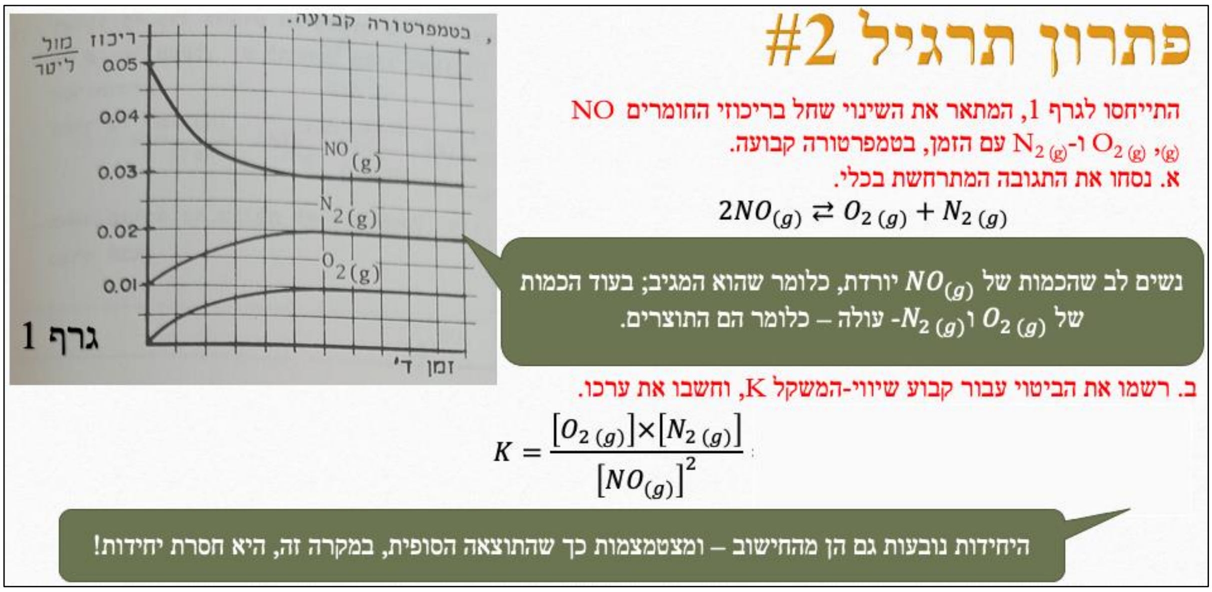


Figure 5. 8: Exercise in Isaac's class relating to chemical equilibrium

Overall, the Israeli teachers Ivanka (who teaches students aged 17-18) and Ilana (who teaches students aged 14-15) used collaborative learning, while Isaac (who teaches students aged 17-18) used teacher-centred instructional strategies. The teachers associated topics with daily life and Israeli-context. All three teachers utilised technological tools while teaching density, DNA, and chemical equilibrium. Ivanka and Ilana encouraged their students to use argumentation when they conducted experiments. Students in Ivanka's and Ilana's classes tended to engage actively, as the teachers in both classes were inclined to use student-centred strategies. Whenever students asked questions, they did not hesitate to answer. The teachers used technological tools, experiment, modelling, and demonstration while teaching. These stimulate students' interest and curiosity and connect the subject to daily life. The next section discusses how Korean teachers deliver their classes.

5.3.3 Professional Beliefs and Virtues (PB&Vs)

Teachers in Israel are influenced by their context-based chemistry curriculum. In their interviews teachers highlighted some socio-scientific issues. When Idit was asked about her professional beliefs about teaching chemistry, she pointed out that

> To be a decent global citizen, I believe that everyone should know a little bit about chemistry. Personally, I like seeing behind the scenes of global chemistry. I believe my life is better now that I understand chemistry. I really believe this. I like encouraging my pupils and/or teachers to share this passion with them. This is what I tell my pupils. We have a matriculation test, and I'm satisfied with their chemical results. Our

> objective as teachers is for them to pass their exams, but more importantly, I want them to enjoy and understand chemistry. If they understand chemistry, they can make decisions regarding pollution or how damaging methane or CFCs are to our ecosystem. Knowing about chemistry forces them to make good judgements (Idit, January 2020).

The excerpt above shows that Chemistry is vital in sustainability issues outside of the professional world. Chemical knowledge helps lay people to understand the issues threatening the planet's sustainability, for instance the mechanisms behind climate change and the effects this can have on our personal lives. Bennett, Gräsel, Parchmann, and Waddington (2005) highlighted that a context-based approach focuses on applying science to enhance scientific understanding of the real worlds of students while developing their capacity to function as responsible participants in their everyday lives. In line with this, Irit responded the same question about beliefs about teaching chemistry, she said

> Chemistry needs to be relevant. It needs to be simple. It needs to be interesting. It needs to be hands-on. It must include a variety of teaching methods. Those are important because students have many opportunities to choose subjects, and you need to make them choose chemistry. Nowadays, students do not like difficulties, so it is important to make chemistry topics fun and interesting and make them relevant. Chemistry is important because it explains what happens around it, so the relevance is really important (Irit, January 2020).

In addition to Irit and Idit, Irene also put emphasis on why students need to study chemistry. When she was asked beliefs about chemistry teaching, she pointed out

> I believe that everyone in the 21st century has to study chemistry to understand the world around them. To make decisions based on understanding, be able to read information connected to science (like pollution, global warming, and more), like medical results, and articles in newspapers. Be able to see through the advertisement (true or false). At the beginning, all I had in mind was to teach pure chemistry. In time, I have seen that chemistry has to be connected to life and be relevant to pupils; otherwise, it does not interest most of them. Curiosity is a big driving force in studying science (Irene, April 2020).

Irit, idit, and Irene focused more about why teaching chemistry is important to us. For example, When Ilana was asked how knowledge of chemistry influence the personal values that she communicates to students, Ilana replied:

> There is a saying like education is not about filling the bucket, but it is about enlighten to the others. I think, I helped students to be a good person. I also helped other colleagues to be a good teacher. As a personal goal, I want to raise my students as a human being and want them to have certain characters, like when they start to work, they should have work ethics and moral characters. I believe this would be helpful for society (Ilana, January 2020).

The excerpt from Ilana shows that teachers might promote eudaimonia which contributes to students' well-being and human flourishing. Therefore, students who are taught by great chemistry teachers might gain moral character which supports society positively. 'In neo-Aristotelian view, wisdom is about making good choices and helping others do the same in virtue of a deep moral understanding of complex human problems, an understanding arrived at through reflection and experience' (Kristjánsson, Fowers, Darnell, & Pollard, 2021). As concluded earlier in chapter 2 one of the distinctive features of being a great teacher is reflectiveness. However, being reflective alone is not enough to gain practical wisdom, which is an integrative way of thinking that enables wise decision-making. Reflection should be supported by moral decisions which lead to moral action.

5.3.4 Professional behaviour and behaviour management

One Israeli teacher put emphasize teachers' behaviour management. When asked what makes a teacher great, Ioane answered as follows:

> Calm and straight and I think when you know what you do you will be a good teacher. If you are confused, students recognise it. I think children are smart at knowing whether a teacher is confident or not when they explain something. So, I think that a teacher should be good at his or her subject. It is one of the keys for good teaching. If they ask questions and you say you do not know, I think your image from the student's perspective will not be good (Ioane, January 2020).

Ioane has 5 years' experience. Ioane has less experience than other teachers such as Ilana, Ivanka, Irene in teaching chemistry. The experience might have led Ioane to describe excellency qualities relating to behaviour. However, for example, Irene pays much more attention to passion along with the pedagogical domain of teaching.

5.3.5 Conceptualisations of great teachers

Findings from the semi-structured interviews with teachers in Israel showed that a main purpose of education should be to educate young minds. Teachers in the interviews also stated that a focus in science teaching should contribute to human flourishing. When Ivana was interviewed, she described herself as a great teacher, then as a follow-up question, the researcher asked how she became a great teacher, and she said:

> At the beginning I thought of myself as great regarding delivering chemistry CK. At the beginning, I just focused on providing students with chemistry knowledge, only knowledge. I was serious about it. I have no compromise; because of that lots of my students said that you are tough. After that I began to think that being a teacher is not just feeding students with knowledge about chemistry. It is more than that. I also reckoned that it was also important to be human and a human being teacher. I think it is another approach to the instruction. I have to deal with and show how to have a good character. They are someone's son and daughter. Teachers should think of their students' academic achievement and moral education though. I try to share my emotions and future plans. I have shared what I have done in my PhD. When students hear that, they respect me and want to be a researcher. That is why earlier I described myself as an educator in addition to a teacher (Ivana, January 2020).

Ivana shows that a great teacher is not only one who delivers CK, but is also one who cultivates their students' moral characters and leads them in the right direction. To be able to do that, teachers should evaluate themselves and critique their development. Biesta (2015) explained the difference between competent teachers and good teachers. He said, "the difference between a competent and a good teacher lies in the ability to bring judgement to the task of teaching" (Biesta 2015, p. 21). Ivana shows that she reflects on her competence. She emphasises wise decision-making about her teaching which might change her students' life. In Ivana's case, judgement as regards her teaching style refers to making students good human beings rather than making them competent people. For example, Isaac takes advantages from people around him, which shows that he is open-minded to learning something new. When he was asked about his personal goals as a chemistry teacher, he replied:

> My formal goal is to have my students critically think of the world around them. My second goal is to get my students to gain curiosity and interest. Working through the system with 10 years in teaching, education systems have beaten the curiosity out of students quite effectively. They came to me most of

> them completely flat line. I am a robot teaching me anything. The third most important goal for me is to avoid creating antagonism. One of things that I have found is that the way science in general, and in chemistry in particular (…). It is a fact that it is being pushed down to students' throat. Nobody likes to be forced no matter how you put it. (…) I have one example. One of my graduates, finished chemistry in my class; she did not like the subject that much. After she started her bachelor's in environmental science, she said she still does not like chemistry. The fact that she was willing to learn even she didn't do well in high school. Because when you fail something, you are inclined not to do it again. She was willing to take a shot again in spite of not being successful at high school. It makes me proud of her. Makes me understand I did something good. This is one of the most important goals called "Primum non no cere" (Isaac, January 2020).

The excerpt above indicates Isaac seeks to facilitate a learning environment where every student can learn based on their needs and abilities. He wants his students to study what they wish to study. Thus, he saw himself as an educator who prepares a comfortable environment for students. He believes that if students are provided with such an environment, then, whatever it takes, they will be successful. Isaac then started describing what makes a teacher great, he said:

> Recognise that each student in the class is a human being. It is important to me that students should be willing to learn. In my eyes, a great teacher is one who find ways all students are willing and able to learn from. Great teacher is something I aspired to. I have long way to go. Luckily, I have great teachers around me. In my eyes, a great teacher is one who constantly improves himself and people around him. A great teacher might be willing to learn no matter how senior he is. Expand his knowledge and knowledge that you have for others. A great teacher is one who needs to learn how his mistake make him a better teacher. And do not be afraid to make a mistake (Isaac, January 2020).

This quotation from Isaac indicates that a great teacher is one who develops himself constantly and is willing to learn. Great teachers also influence people around them. That characteristic of a great teacher refers to passion. In this study, passion emerged as a theme that makes a teacher a great. As Isaac states in his first sentence, great teachers should see their students as equal human beings, which is important for students' well-being. Teachers are not only responsible for delivering subject-specific knowledge, but also for coaching students and showing moral character. Irit in her interview was asked what personal goals are the most important in her work as a teacher. She said:

> First of all, to educate students. I am not a chemistry teacher. I am an educator. I need to be an exemplar person for students such as how to behave, how to be honest, how to be a human being. This is the first

> goal before chemistry. They need to feel that the teacher is not an instructor. A teacher is a person that cares about their students (Irit, January 2020).

Similarly, quotation from Idit below shows that being an educator comes first. She said that

> [A] Teacher should not discourage students. [A] Teacher should be an educator. What makes a teacher great is coming from being an educator. It does not matter where you teach and which level. First, being an educator is important. In Israel, I am a teacher of chemistry, but I am also an educator; it means that you have a class and you are responsible for them; if they have any problems, you contact with their parents. So, I said to my students, I am an educator in chemistry; I am not your teacher (Idit, January 2020).

Although delivering content to students is significant, the students also need a teacher who cares about students' well-being in and out of the classroom. Arthur et al. (2015) stressed that the concentration on students' most basic academic skills has grown to the neglect of moral, civic, aesthetic, and any other form of developmental potential that cannot be measured by standardised tests.

In general, the data from each Israeli educator point to the fact that being a great teacher is related with becoming an educator. The vast majority of educators who were interviewed emphasised, regardless of the circumstances, that they believe their first responsibility is to educate their pupils, and only then should they concentrate on the academic accomplishments of those students. A number of educators, including Idit, Irit, and Ilana, brought attention to the concept that instructors have an active role in bridging the gap between the academic world and the wider population. Therefore, these educators thought that training young brains was essential for the health of their students and that doing so would prepare their pupils for the subsequent stage of their life. The profession of teaching in Israel was seen by educators there as one that helps instill ethical and civic values in pupils, so strengthening the bonds that bind members of society to one another.

5.3.6 Teachers' professional development in context

In Israel, PD utilises a cascade model to improve teachers' subject-specific knowledge to address shortfalls in teacher supply, as teachers are recruited from a variety of backgrounds. Taking PD is mandatory in Israel. Teachers must take 60 hours of PD each year. Teachers attend community-based PDs aimed at enhancing their nonspecialist SK and PK. In the semi-structured interview with Inbar, she was asked which PD has had the most significant impact on her practice as a teacher. She responded:

> [The] comminates of chemistry teacher here in Weizmann Institute of Science has the most significant impact on my teaching because it does not focus on one particular thing. We can talk about everything in the community. It is not restricted to doing one thing. We do lots of things that can develop my teaching in many ways such as developing diagnostic tests, producing stories relating to chemistry, doing experiments. Second, it is very important for me at least in Israel on average we have one or two chemistry teachers in school. So, it means, you do not have another chemistry teacher in your school to talk with about your problems and to ask questions (Inbar, January 2020).

The excerpt showed that community-based PD in Israel provides teachers with an environment where teachers share everything with each other. community-based PD in Israel focus on how teachers contribute to students' learning consistently. To do that, community-based PD place reflection at the centre. Ilana highlighted how community-based PD works, saying:

> We are doing activities which focus basically on reducing teachers' misconceptions about subjects that they teach. This helps students to understand the topic better. We (as leader teachers), therefore, generate diagnostic questions and then want novice teachers to take it to their class and then we asked them to come with results. We look at the results and then we think together and then try to deal with misconceptions that students have; then we develop instructional strategies. Therefore, I would say that communities are another world. So helpful (Ilana, January 2020).

Ilana as a leader teacher believes that communities are the best places to practice and develop educational tools and materials together. Teachers in community-based PDs bring evidence from their classes and discuss together how to deal with issues in the classroom. community-based PDs in Israel try to cultivate intellectual virtues. For instance, Ilana mentioned reflection. Ivanka in her interview was asked how the PD enabled her to update her knowledge of science. She pointed to another dimension of intellectual virtue, that is, good questioning. She said:

> Participation in various activities in teaching learning communities allowed me to meet scientists, other colleagues, and academics. What I have learnt from them is preparing good questions is the essential part of getting students engaged in the classroom. Those communities help me to ask high level questions to

> students. Once [when] I conducted inquiry-based classroom, I recognised how significant [it is] to ask good quality questions to lead the class (Ivanka, January 2020).

Good questioning is considered as an important tool to develop intellectual virtues such as intellectual autonomy, intellectual humility, intellectual courage, and inquisitiveness (Watson, 2018). Teachers who have misconception-free CK tend to ask high-order questions. Therefore, community-based PD in Israel concentrates on developing teachers' chemistry, biology, or physics CK.

The findings from PD observation supported statements from the semi-structured interviews. The Weizmann Institute of Science provided teachers with two types of communities i.e., community-based PD for leader teachers and community-based PD for less experienced and newly qualified teachers. During the meetings, teachers conducted action research (AR) activities and focused mainly on common misconceptions that their students might have; instructional strategies that they used in their classroom; diagnostic tests for students; pedagogic knowledge; some hands-on activities that may apply in the classroom; and collaborating with academics who come from other disciplines like psychology, education, and engineering. Leader teachers came together to develop ideas and to generate instructional strategies for new trainee teachers. The learning community that I attended on 15 January 2020 had two sessions. The first session, which was run by Ilana, was about sharing experience and reflective practice. Teachers shared their experience on what they have done in the classroom. One teacher would stand up and explain to the others what worked in his or her classroom (see Figure 5.9). Teachers also brought materials that they had prepared and applied in the classroom.

Figure 5. 9: Images from community-based PD in Israel

The second session constituted a group discussion, followed by hands-on activities. Collaboration, sharing, and cooperation were the most important values in the community-based PD, as they enhanced teachers' knowledge and beliefs as they listened to colleagues and the ways in which they handled misconceptions and create a better environment for students. The learning community was run by a leader teacher, who explained and transferred the information from the previous community-based PD leader teacher meeting. This type of learning community aims at creating more leader teachers, who volunteer to run other community-based PDs and prepare better teachers for students in Israel. In the community-based PD leader teacher meeting, newly qualified teachers came from different parts of Israel to update their knowledge by meeting more experienced colleagues; learning new hands-on activities; collaborating in discussions about diagnostic tests; discussing misconceptions about science classes; and improving their networking through various activities. The 'community-based PD close to home' that I attended focused on classroom management. A leader teacher who was responsible for the session had invited a psychologist from the Institute of Science in Israel. She gave a presentation about how to manage time effectively and wisely. A second session started with a presentation, which focused on misconceptions about oxidation. First, teachers came together to discuss oxidation (see Figure 5.10). After their discussion, they engaged in a hands-on activity about oxidation. The leader teacher had already prepared the kind of hands-on activity she wanted their colleagues to do (Figure 5.10).

Group discussion

Hands-on activity

Figure 5. 10: Collaboration in community-based PD in Israel

In another session, an academic from a university in Israel gave a workshop on neuropedagogy. She explained her research and shared her results with the teachers. She also prepared some diagnostic questions and shared these with the teachers. The participants liked the way she presented her work. It was not a traditional lecture-style workshop. All the teachers participated actively. In Israel, while community-based PD leader teachers focused mainly on developing ideas and developed some necessary skills for science teaching, community-based PD close to home was aimed at developing great chemistry teachers. Leader teacher meetings also helped teachers to develop their leadership skills. In Israel, community-based PDs are places where new ideas come up and are shared with other teachers. Since PD is mandatory in Israel (60 hours a year at least), teachers tend to attend community-based PDs provided by the Weizmann Institute. Those communities enable teachers to reflect on their practice. Leader teachers such as Ilana, Ivana, Idit, and Irit help other teachers to be reflective on their practice. Building community-based PD where teachers exchange knowledge and share their ideas helps teachers gain reflexivity. Figure 5.11 shows outlook of PD activity in Israel.

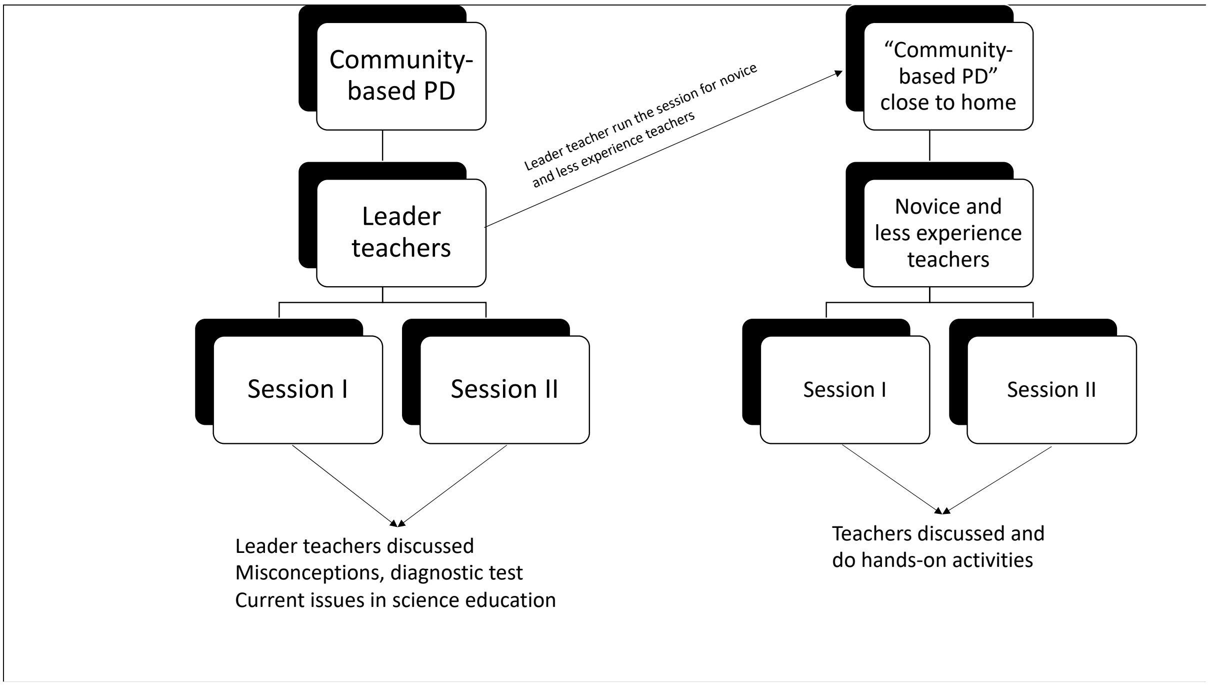


Figure 5. 11: Outlook of PD activity in Israel

Overall, interviews and observations in PD in Israel promotes the formation and growth of community-based PDs, which are a bottom-up method of introducing collective practice into science curriculum. The diagnosis of students' misconceptions and generating diagnostic tests were a primary topic of discussion in community-based PD workshops for chemistry teachers, with the goal of matching new teaching methods to the students' specific learning characteristics. However, the community-based PD activity should also include shared reflections on the teachers' own ideas, issues, and conceptions in order to discover and overcome knowledge gaps. Collaboration between academics and teachers at Weizmann support teachers to gain different ideas and solutions on students' misconceptions which help teachers to address knowledge gaps.

5.4 Case III: South Korea

South Korea is the only country where all data sets were collected. The semi-structured interviews (see Section 4.10.1), classroom observations (see Section 4.10.2), observations in PD (see Section 4.10.3), and focus group interviews (see Section 4.10.4) were designed to capture similarities and differences regarding perceptions of great teacher and teaching among chemistry teachers of 14 to 18-year-old students in South Korea. Based on thematic analysis, six distinct themes emerged. Each of these is discussed in turn. The next subsection discusses evidence relating to CoP from all the data.

5.4.1 Community of practice (CoP)

While asking teachers' opinions about PD, Sung-Sook described how PD supported her development as a teacher:

> I would say that I update my knowledge through PD where interaction and effective partnering take place. It helps me to gain different perspectives and new horizons. Constructivist and well-facilitated dialogue enabled me to generate better ideas with regards to students' misconceptions or develop my instructional strategies. Sharing materials, discussion, presentation, getting to know each other, beneficial sites are the key to exchange of knowledge, which in turn [helps] developing my instructions, knowledge, and professionalism. (Sung-Sook, October 2019).

This excerpt indicates that PD provides Sung-Sook with an environment where mutual engagement takes places through effective partnering, collaboration, and cooperation with other colleagues. This mutual engagement between teachers also facilitates learning and contributes to meaning-making. In her interview, Su-Mi indicated how she thought PD contributed to her development:

> I think that when I come together with other teachers, I gain new knowledge faster than I do by myself. Some teachers in this community have already come across the problem that I have experienced. So, when I ask them how to handle for example classroom management, there is always someone to have an answer. I think the point to attend to PD is to get different perspectives and apply them to your classroom. So, I find collaboration with other teachers useful, and I try to spend time with other teachers (Su-Mi, October 2019).

This excerpt indicates that PD helps extend Su-Mi's repertoire with regard to handling problems. As teachers may have experienced the same difficulties or problems, it is important to know beforehand what kinds of difficulties or problems could arise in classroom settings. PD activities provide teachers with an environment where they can practice 'mutual engagement', 'joint enterprise', and 'shared repertoire'. These are three dimensions of Wenger's CoP (Wenger, 1998). As indicated in the quotations above, teachers who attended PD activities experienced mutual engagement, joint enterprise, and shared repertoire with colleagues. Hence, PD is considered as a community in which teachers practice their knowledge and area of teaching expertise with other colleagues. The focus group interviews with the teachers identified attending PD as a factor that might influence their teaching practice, instructional practice, motivation, behaviour, and professionalism. During the focus groups teachers were asked about attending PD (Statement 1). I asked them to discuss the question: 'Do you consider PD contributes to great teaching?' Su-Ran explained why she found attending PD to be important:

> Not only do I reflect on what I have learnt from PD activities, but I also use instructional strategies actively in my class. I adopt various activities and experiments which I learn from PD. It is also a great opportunity to meet great teachers who come from different parts of Seoul. For example, master teachers in PD observe us and share their experience. The more I meet different teachers, the more I gain experience and knowledge. As I meet them and see what they have done to handle classroom situations, I also do self-evaluation and self-reflection. You know, I also challenge the experiment that I have never had before. Whenever I come here, I feel motivated to teach the best class for my students (Su-Ran, October 2019, Focus group 2).

The excerpt above indicates that PD not only helps improve teachers' PCK, but it also supports teachers' professional behaviour. Seon-Mi is a master teacher. She is one of chairpersons of Shingwaram. She said she got lots of benefits from PD in general and from Shingwaram in particular. Being a master teacher, she also helps other teachers to develop. In her initial interview, she explained the responsibilities of a master teacher:

> What I usually try to do is to observe other teachers, a series of lessons, because I believe that as we observe each other, we can have a look at each other from different aspects. For example, I go to observe different classes like Korean, English, social studies classes to gain something which I can adapt to my classes. Moreover, having observed the class, I give my thoughts and impressions as well as my critique to my colleagues to improve their expertise in their subject area, although I am not that much of an expert. That is what a master teacher is responsible for (Seon-Mi, October 2019).

The excerpt above shows that Seon-Mi as a master teacher coaches other teachers. This coaching does not necessarily have to be subject-based. She helps other teachers' PCK development and other needs such as psychological needs. When she was asked which PD experiences had supported her practice as a teacher, she explained:

> First, Shingwaram focuses on science. Experiments are mainly done during the sessions. We are doing hands-on activities that can be done with students in the classroom. Currently, apart from experiments, in

> Shingwaram we have also presentations related to how to improve teaching methods. Until several years ago, it has focused solely on hands-on activities. When it comes to cross-curricular communities and activities, we discuss more about teaching methods rather than doing experiments. We for example discuss how to write a project, how to do group evaluation, how to organise students into groups, how to reflect performance assessment etc. I can clearly say that I applied 80% of the regular activities in the classroom that I learned from Shingwaram. I also put my judgement on how to regulate those that I learned from there, but definitely I learned the basics from Shingwaram (Seon-Mi, October 2019).

The excerpt indicates that PD develops her PCK in general. Additionally, PD helps improve her perspective. She states in the quotation that follows how she is influenced by PD:

> I am a chemistry teacher, but this course is designed for science teachers who teach other science subjects as well like chemistry, physics, biology, earth science. So, my out of field knowledge increases. Somehow, as you know, chemistry is related to other science. I try to learn as much as I can from other teachers. It is also a fact that I do not think my chemistry CK is increased but learning about other science subjects provides me with better understanding of what science means (Seon-Mi, October 2019).

The excerpt indicates that Seon-Mi is open-minded and gets benefits from activities which are done together collaboratively with teachers from other science backgrounds. This collaboration helps her understanding of chemistry as an interdisciplinary subject and also influences her beliefs about what to teach and why to teach it in chemistry class. So-Yeon is a chemistry teacher with 17 years' experience in teaching. What she has found the most beneficial PD is 'a study group/research group' with four teachers who come from different science backgrounds. In her interview, she explained how she got benefits from PD which support her PCK and PB&V.

> It is significant that a science teacher should teach his subject perfectly and SK might be one of the most important to do so. However, I think it is also so important to make content easier for students to access, no matter they have curiosity or not about learning science. Making science contents accessible and easier for students are crucial skills because we are living in a technological era. Therefore, three other teachers and me established a study group/research society to make some difficult contents easier for students. Moreover, nowadays, no matter whether smart phone or another technological tool, technology usage in the classroom and chemistry laboratory has developed. Especially, science teachers in South Korea use Arduino software. I also let my students build a sensor kit to test conductivity and temperature using Arduino. I want students to combine with their different skills. They have also coding class. So, I want them to use what they have learnt and how they apply it to chemistry. Therefore, I not only have a study group but I also work with other teachers collaboratively in my school. I try to get students to gain hands-on skills,

> which are quite important in chemistry, I think. In addition, I try to make them familiar with digital literacy (So-Yeon, October 2019).

This excerpt from So-Yeon indicates that the research group that she established with the other three teachers not only develops her technological pedagogical content knowledge, but also contributes to the ways she connects chemistry with other subjects. She recognises what students need and tries to prepare a class based on students' needs. South Korea is a knowledge-driven society where technology is integrated into everyday life. Therefore, So-Yeon wants to teach her students how to use technological tools in the classroom and laboratory so as to make students' life comfortable and easier. Si-Eun has 14 years' experience in teaching chemistry. She pays attention to societal issues and has developed PD on socioscientific issues. In her interview, she said:

> We have sort of development courses which are about 'issues out of curriculum'. In summer and winter vacations as well as in semester times, we have lots of development programmes for teachers. I have attended them in my free time. I had a course which lasted a week every day from 9am to 5pm on holiday. We tried to produce new programmes about issues in science education. I am interested in some societal issues and how to sort them out. When you think about Korea, in the West, we have China and they produce air pollution, in the East we have Japan and they produce radioactive pollution. Therefore, in our summer PD course for example, we had 14 classes about radiation so we all discussed radiation and did experiments about radiation. We deeply discussed about it. Intensively, we are making a programme. As we make a new programme, so I can use it in my class. Though what we aim at is to do meaningful class for students. I prefer doing it with other teachers in a PD programme to creating something alone (Si-Eun, October 2019).

The excerpt above indicates that Si-Eun is aware of some of the societal issues happening around South Korea that impact the country adversely. Therefore, she prefers to attend PD programmes which contribute to her knowledge expertise because she believes that scientific knowledge is power and helps us better understanding where we live. The situated learning experience enables her to be involved in activities where she develops her intellectual and civic virtues skills (Lave & Wenger, 1991). Seo-Jun's expertise is in biology. He has 30 years' teaching experience. He is also working as a general manager in the school. He also attends Shingwaram regularly. When he was asked 'Which PD experience has had the most significant impact on your practice as a teacher?', he stated:

> I think for me courses relating to teaching methods are helpful. I also get benefits regarding courses which are organised by experienced teachers on the ground. It is really helpful because I can learn "know-how" matters which students and I need. So, courses which are led by teachers are helpful, as they bring their teaching methods, materials, feedback, everything to class and we discuss something which has already been adopted in the class; but in the case of a lecture, experts come to us to explain some theory, so I do not think it helps my practice. In Shingwaram, for example, teachers apply different sorts of strategies in their class to improve students' academic achievement. Then they explain the advantages and disadvantages of teaching methods that they applied. So, when I learn about pros and cons, I create my own strategies. They give us some tips on how to make sure students do not fail or how they can become successful. We also have hands-on activities and some technicians who update us about laboratory tools. Each teacher has different strategies; like some teachers like developing games; some teachers are more close to technological tools; some teachers are more active and doing some research abroad and bring their data and present to us. So, we have a sort of synergy and we share everything (Seo-Jun, October, 2019).

The excerpt above indicates that PD courses which are run by teachers are more effective than those which are organised by experts (people who do not have a teaching background). Seo-Jun uses his critical judgement to decide whether the activities in the PD will contribute to his teaching before he puts strategies into his repertoire and so shows that well-developed PD provides teachers with new perspectives and develops their wise decision-making ability. What teachers said in their interview and focus group interview also were observed in community-based PDs. At a PD activity which was held on 22 October 2019 in South Korea, So-Hyun explained how to make a flexible electrode with slime. Figure 5.12 shows the structure used in So-Hyun's session. She explained the theoretical background behind the experiment in the first 10 minutes. A handout prepared by the teacher gave detailed information about the experiment. She then started with an introduction about polymers and batteries. She continued by explaining oxidation-reduction reaction, chemical cell, and a Daniell battery. Finally, she explained how to do the experiment. This session focused on how to produce a flexible electrode using polymers. The reason why So-Hyun did this experiment was to show her grade 12 students that a chemical cell is a device that converts chemical energy into electrical energy using an oxidation and reduction reaction.

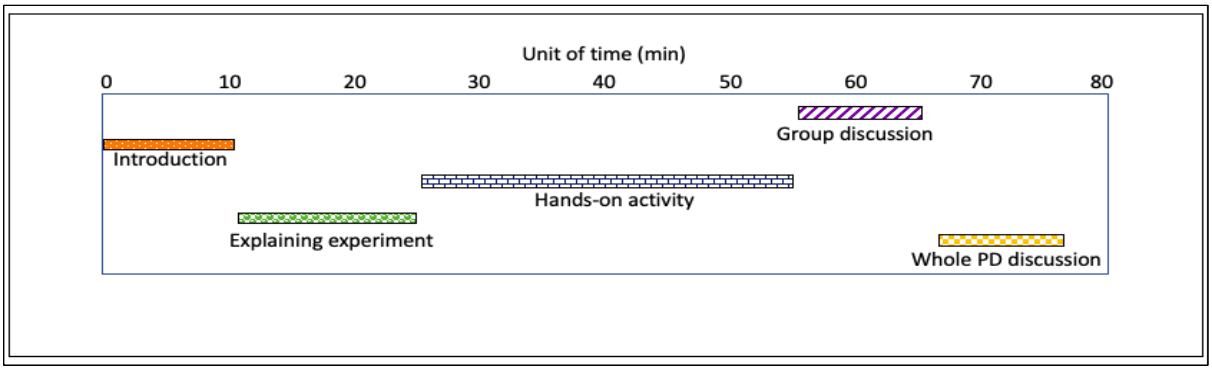


Figure 5. 12So-Hyun's PD session structure

After So-Hyun explained the experiment, teachers started doing the hands-on activity (see Figure 5.13). This activity helped teachers exchange ideas and promoted opportunities to update knowledge on electrochemistry. The session provided teachers with an instructional strategy about how to interrelate two topics, namely polymers and electrochemistry.

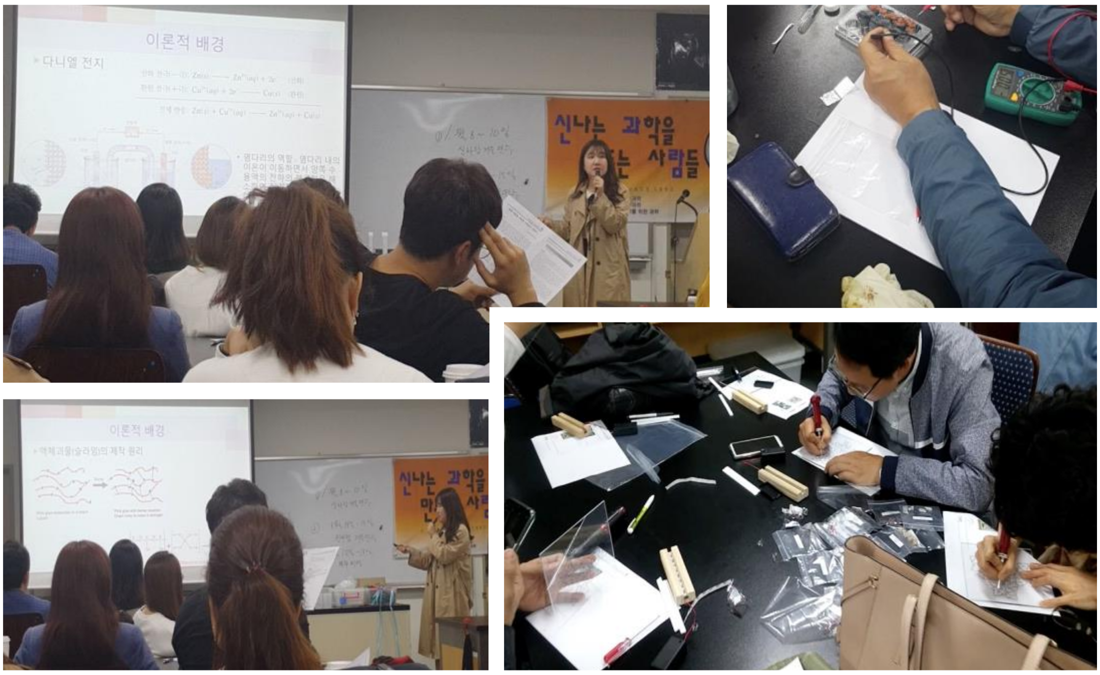


Figure 5. 13Hands-on activity in So-Hyun's PD session in October 2019

In a PD activity held on 1 October 2019 in South Korea, So-Heon introduced a card game to explain covalent bonding to her grade 9 students (14-15-year-olds). Before she started the session, she distributed handouts. She used the same session structure as So-Hyun (see Figure 5.14). She introduced the topic and gave background information about Lewis structure. She explained how to play the game and provided time for the teachers to play it. She then followed up with a group discussion where she asked each group to present its thoughts and opinions about the card game.

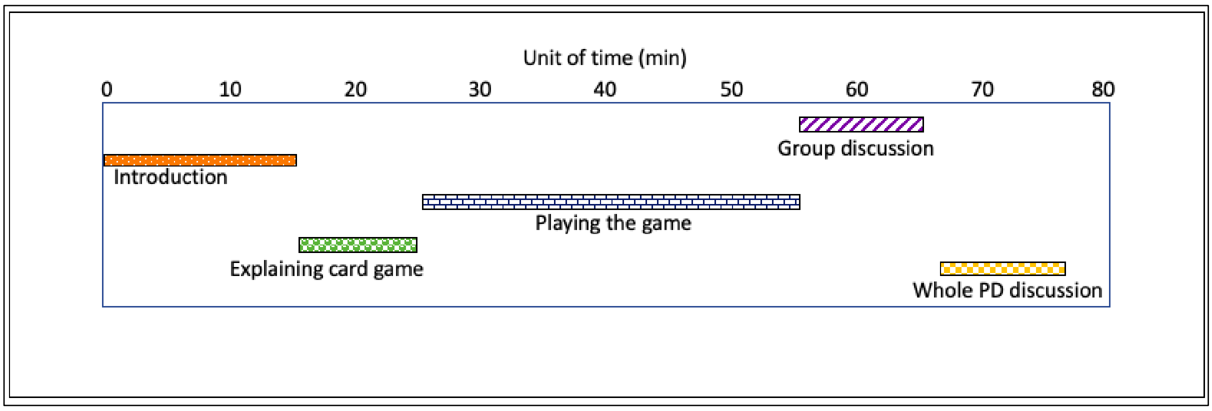


Figure 5. 14So-Heon's PD session structure

So-Heon is a novice teacher with 2-years' experience in teaching chemistry at grade 9 to 12 (14-18-year-old) students. She designed a new card game to introduce bonding to students. This PD session provided a new insight into how to teach students about bonding in a fun way. This card game encouraged teachers to apply this card game to teaching other topics. This session indicated that teachers who collaborate in PD encouraged each other and produced new insights.

5.4.2 Pedagogical content knowledge (PCK)

In line with the semi-structured interviews, the focus group interviews with teachers also showed that PCK is an important pillar for becoming a great teacher. During one focus group session in which teachers discussed teacher professional knowledge, I asked them a leading question, that is, 'How does your professional knowledge influence students' learning?' Su-Nam said that

> As a teacher I am responsible for creating an environment where students investigate knowledge by themselves, then I want them to relate that knowledge with societal issues and life. I am enthusiastic about raising my students as an individual learner, who can be able to generate knowledge by themselves (Su-Nam, October 2019, Focus group 2).

Su-Mina made a similar statement in another focus group discussion. However, she used a proverb to explain her ideas:

> "Give a man a fish and he will eat for a day. Teach a man how to fish and you feed him for a lifetime". I tend to teach why chemistry should be taught rather than transfer chemistry knowledge to students without grasping the core value of science. I want my students to gain scientific reasoning skills, then they can discover how exciting chemistry is by themselves. I would say, as a science teacher I am just here to teach the ways that my students reach knowledge, not giving everything to them (Su-Mina, October 2019 Focus group 4).

Both Su-Nam and Su-Mina indicated that student-centred teaching requires inquiry-based teaching strategies. Creating a classroom environment in which students are motivated to learn science requires high-quality instruction and so is linked to high-quality CK-PCK connection (Kind et al, 2022). Previous studies have shown that high-quality instruction impacts on students' outcomes and learning significantly so long as teachers have enough time to apply it in the classroom. Soo-Youn from focus group 2 said:

> I agreed with Su-Nam. However, no matter how passionate and willing I am to teach different perspectives to my students, there is a reality that I am also responsible for following the curriculum for the exam. I really want my students to investigate and do more experiments, but we do not have enough time to perform everything. Let's say I spend 70% of my time on preparing my students for the exam, and the rest of the 30% of my time I try to do some noncognitive exercises. For me, teachers first should present the best curriculum knowledge then present other things (Soo-Youn, October 2019, Focus group 2).

Sue-Hyon from focus group 1 had a similar perspective to Soo-Youn's. She pointed out that

> I am working in a high school where students just think about entering a prestigious university. Actually, this is what their parents want from them. Therefore, my priority is to let them pass the exam. After that, I can focus on going the extra mile my students. I wish I could be spending more time engaging my students critically in the class. (Sue-Hyon, September 2019, Focus group 1).

These excerpts from Sue-Hyon and Soo-Youn show that teachers should follow the curriculum for various reasons. For example, teachers who teach in nations like South Korea, Israel, and Turkey where students take exams to get into university tend to focus mainly on following the curriculum. This focus leads teachers to attend subject-specific PD. The next point discusses how PCK contributes to the classroom teaching of teachers in South Korea. South Korean teachers encouraged their students to participate actively. The teachers tended to prepare student-centred classrooms. Seon-Mi for example explained alkynes in her class. Figure 5.15 shows Seon-Mi's lesson structure. Prior to starting alkynes, she recapped on what polarity and nonpolarity are (Figure 5.16). She associated polarity with human relationships. She brought a quotation written by a student and put it up on the whiteboard to explain polarity.

Seon-Mi: This is a posting written by one of my students. I wanted my students to write something which explains polarity and nonpolarity in different ways. This is my favourite one. This was written by a male student.

"My heart is polar, but seeing you melting in my heart, you must be polar too."

Seon-Mi: This expression was written after I had taught the relationship between polar and nonpolar molecules. It is expressed in this way that polar or nonpolar molecules are not friendly to each other. After you learn the definition, you do not need to memorise it. Create something, which enables you to remember the definition.

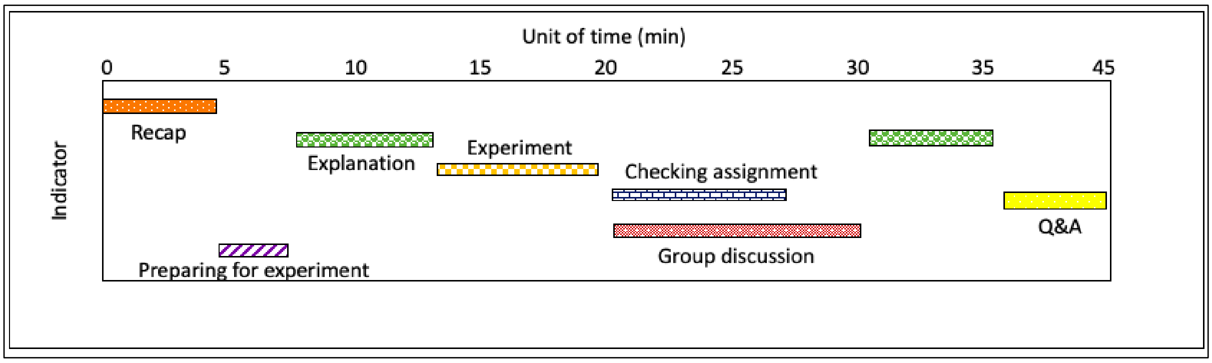


Figure 5. 15 Seon-Mi's classroom teaching structure

The excerpt from Seon-Mi's class indicated that she encouraged students to use scientific language as a part of their life. She does not lead students towards rote learning. She instead encouraged her students to think creatively. This is a way that a great teacher cultivates students' intellectual virtues.

Figure 5. 16Warm-up activity in Seon-Mi's class

After spending 3 minutes showing some of the students' other quotations, she started answering questions from the previous lesson. One student asked:

> **Student:** As we learnt, if the electro-negativity difference is greater than 1.7, this causes the formation of ionic bonds. Then my question is, although HF's electro-negativity difference is greater than 1.7, why not HF is ionic?
>
> **Seon-Mi:** There are some exceptions in chemistry and a formation of HF is one of them. Actually, it is better to have a look at electron density or a charge density map of atoms. It gives better ideas whether compounds are iconic or covalent. There are some rules in chemistry you should know them but it does not necessarily mean you have to memorise them. You always need to critique why it does matter. This question also comes up from other students. So, I was expecting you to ask it actually.

This student wanted to learn the reason behind why HF is doing a covalent bonding. Seon-Mi replied without hesitation because she knew that students raise this question about HF. She demonstrates intellectual action. She did not say to her students: 'It is an exception, and you should memorise it'. She instead showed there is another way to understand what lies behind the exception. Her response also showed that Seon-Mi has a range of CK, which enabled her to explain the topic from different perspectives. She demonstrated an experiment to explain alkynes. Before she started to do the experiment, she asked the students: ‘What happens when CaC_2 reacts with H_2O?’ (see Figure 5.17).

Student: I think, it ends up with producing calcium hydroxide and acetylene

Seon-Mi: Yes. That is right. If calcium carbide reacts with water, then we have an alkyne as a product called acetylene (ethyne). How about the combustion of acetylene?

Student: Carbon dioxide and water

Seon-Mi: Yes definitely. So, today we do an experiment about how to produce alkynes.

Seon-Mi used flipped learning as an instructional strategy to explain alkynes. Having finished the experiment, students wrote questions about the experiment and alkynes in general on the board (see Figure 5.18). Seon-Mi uploaded videos and materials relating to alkynes on Google classroom. The students had already watched and studied these beforehand. When they came to class, Seon-Mi performed the experiment and responded to students’ questions.

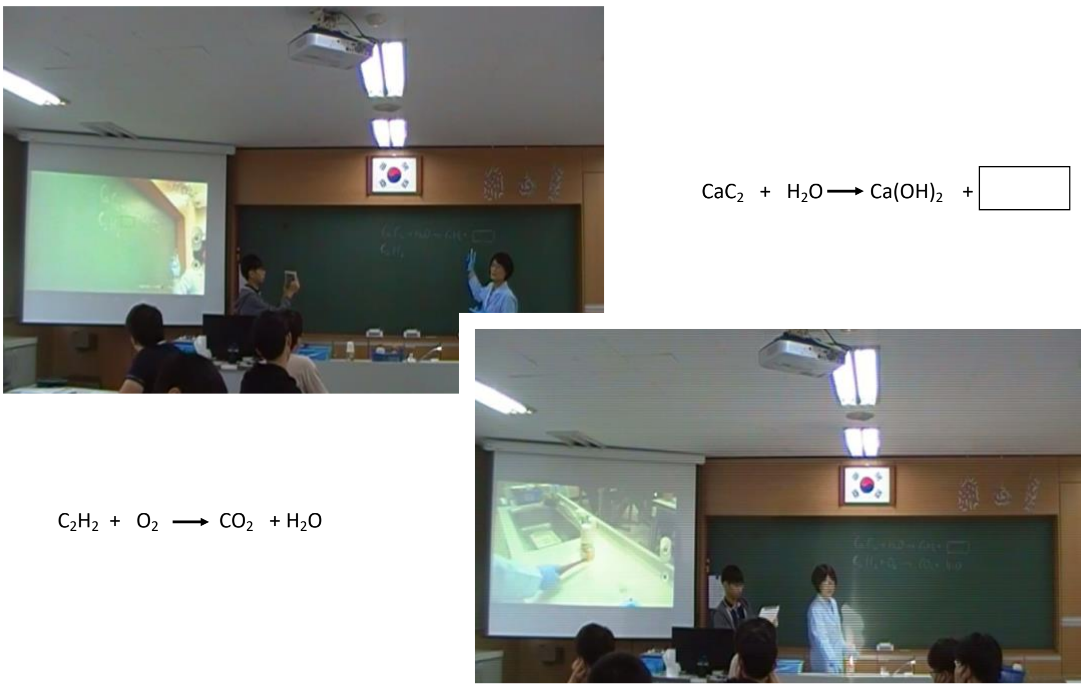


Figure 5. 17Experiment to explain alkynes

Question on the board

Do Alkene and alkynes both have
Flat structures?

Figure 5. 18 Seon-Mi's flipped learning classroom

Seon-Mi used particular strategies and methods to hook the students' attention. She applied flipped learning in her class. The students in her classroom were free to ask questions. She did an experiment to explain alkyne chemistry. After the experiment, she explained the properties of alkynes using modelling (see Figure 5.19).

Seon-Mi: What is this? (C_2H_6)

Students: Ethane

Seon-Mi: Yes. Ethan ~ 2 Carbon ~ 2 Oxygen Do you understand? So, what happens if one oxygen is added here?

Students: Propane

Seon-Mi: Yes Propane. When it comes to propane, one oxygen here has to come off, right? The point is, as the number of oxygen increases, the angle between this carbon and this carbon is not a straight line. When you look at ethane, there was a straight line between this carbon and this carbon. Even if only three carbons are attached, the shape is already crumpled. So, as it gets longer, it gradually becomes a zigzag shape…

Figure 5. 19 Seon-Mi uses modelling to show alkynes

Se-Hoon's based her teaching on didactic teaching, with some active participation from students. Se-Hoon's lesson structure is shown in Figure 5.20. Se-Hoon taught about the steam engine, enthalpy, and the first law of thermodynamics. No group or whole class discussion was observed.

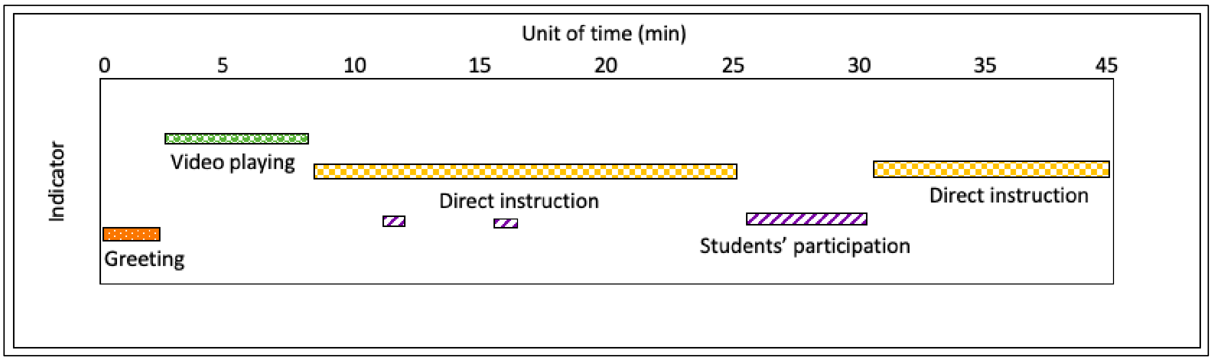
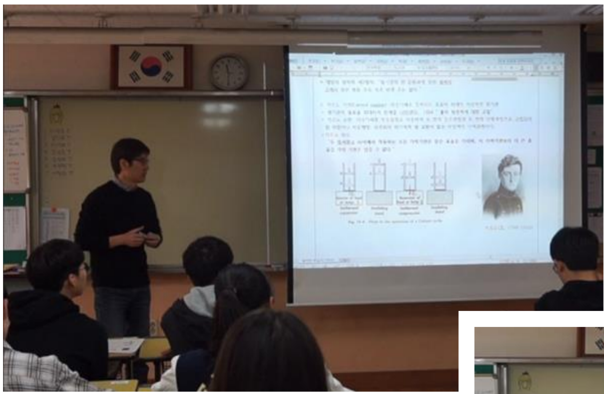


Figure 5. 20 Se-Hoon's classroom teaching structure

He used direct instruction. He prepared a PowerPoint presentation. Before he started to teach about the steam engine, he played a video on YouTube relating to the steam engine and its history (see Figure 5.21). While Se-Hoon was explaining about the Carnot engine, he also mentioned how long he had spent choosing the best video to show his students. He said he spent 3 days choosing an appropriate video to show his students. When his students heard that, they respected him more.



Carnot heat engine

Steam Engine

Figure 5. 21 Se-Hoon uses technological aids to explain steam engine

When Se-Hoon explained the Carnot engine, he directed a couple of questions to his students. An excerpt from the dialogue between the students and Se-Hoon is shown below:

Se-Hoon: So, what Carnot wanted to solve is that you make a steam engine and use it in many places. What are the most important things about a steam engine? For example, what is the most important thing in a car?

Students: Engine

Se-Hoon: What is in the engine?

Students: Fuel economy, fuel efficiency

Se-Hoon: Yes. In other words, how many kilometres does one litre of petrol enable you to go? Are you going at 10 km per hour? Are you going to 12 km? At that time, they used steam engines to work and the goal is to create an engine that does more work when the same amount of oil is burned.

Se-Hoon also encouraged his students to reflect on what they understand about the topic. When he was solving a question on the Carnot cycle, Se-Hoon wanted a student to solve the problem on the board (see Figure 5.22). One student raised his hand and tried to explain to his friends. He stood in front of the whiteboard and started to explain the way he solved the problem. When he had finished and gone back to his desk, Se-Hoon asked his class a question.

Se-Hoon: Do you know what is the most important thing for success? It is confidence. You know what is written on the back of your friend's clothes? Confidence is important!

Figure 5. 22 Active participation in Se-Hoon's classroom

Sang-Cheol used mainly hands-on activities to explain redox reactions and specific heat capacity. Sang-Cheol prepared three experiments to show redox reactions and explain heat capacity. First, he demonstrated what happens when potassium chlorate (KCl_3) is combined with sugar. Second, Sang-Cheol demonstrated how to boil water in a paper cup. Lastly, Sang-Cheol demonstrated how to paint with fire. Sang-Cheol's experiment is shown in Figure 5.23.

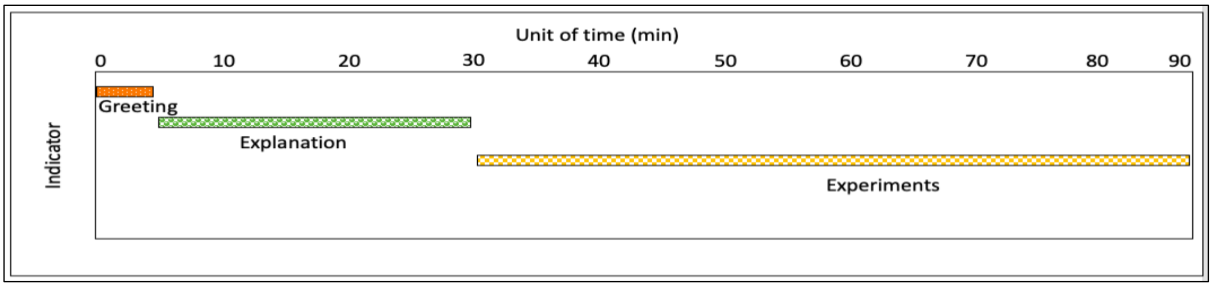


Figure 5. 23 Sang-Cheol's laboratory structure

In his interview, Sang-Cheol highlighted the reason why he attended PD in Shingwaram.

> Especially as a teacher, who loves doing experiments we in this PD do lots of hands-on activities. Indeed, I am much more interested in visualising by doing experiments. Therefore, even I have less time to do experiments, I created time out of class to show how theoretical knowledge works in reality. Sometimes

you know what theory says and what reality shows might be different. If I show this to students, they will also think critically. Doing experiments is important to argue the reality.

As the excerpt shows, he believed that experiments are one of the most effective ways to deliver chemistry knowledge to students.

Overall, all three teachers in South Korea employed organised resources and materials to promote students' attention and motivation. Seon-Mi used technological tools and integrated them into the teaching. Se-Hoon also used PowerPoint. Sang-Cheol prepared experiment tools and PowerPoint slides to explain what kinds of experiments he would do during the laboratory session. Seon-Mi created a corner called 'a voice of student'. She collected evidence from her students. She wanted her students to draw a picture in relation to the subject that she was going to teach. She started her lesson by sharing a poem. Then she connected this poem to polarity and nonpolarity while explaining alkynes. The South Korean teachers generally used technology in their classroom. They made their presentations visually attractive as a way to attract their students.

5.4.3 Professional Beliefs and Virtues (PB&Vs)

While asking teachers' opinion about great teacher. The excerpt below, which comes from So-Yeon's interview, indicates what she thinks a great teacher looks like. She said:

> I think I can describe teaching as a direct action. Teaching is not just about delivering the content to students (of course it is necessary); teaching is much more about making students engage critically into learning process through questioning. I believe that students can access topic-specific knowledge easily on the internet or they can learn knowledge from me. However, if scientific knowledge is not analysed and questioned critically by students, then students cannot gain judgement ability on what is necessary or not live comfortably. Therefore, as a teacher I am responsible for creating a positive learning environment and cultivating their intellectual and personal education through mutual engagement (So-Yeon, October 2019).

Sung-Sook had the same opinion as So-Yeon on how teaching should be:

> I want students to gain curiosity and interest, keep questioning and try to understand the reason behind that phenomenon. Why is that? How can it happen? I really want to raise students who question some scientific issues, whether it is true or not. I do not want them to take everything directly… I want to have students who realise the implication of science on society and its impact on society… I want to be a teacher

> who helps and coaches others. I am a running chemistry club with my students. I take my students to a children's community centre and my students teach science there (Sung-Sook, October 2019).

The perspectives offered by So-Yeon and Sung-Sook emphasise the significant impact that educators have in fostering not only students' acquisition of information, but also their development of intellectual virtues, including attributes such as curiosity, critical thinking, open-mindedness, and discernment. These features are suggestive of qualities that are inherent to an exceptional educator. The prioritisation of cultivating these qualities within the educational setting is consistent with the overarching goal of education, which beyond the simple dissemination of knowledge and instead aims to cultivate persons who possess a comprehensive range of skills and intellectual capabilities.

Sung-Sook's recognition of the significance of inquiry and critical thinking as fundamental abilities for students in their comprehension of science exemplifies the attributes of an exceptional educator. Sung-Sook acknowledges that genuine scientific literacy is more than just rote memorization of information. It entails the capacity to critically interact with the subject matter and effectively apply it to practical situations in the real world.

In addition, it is crucial for educators to recognise the significance of comprehending students' preexisting knowledge and attitudes towards learning, as emphasised by Baehr (2013), in order to effectively foster the growth of their students' intellectual character. According to Baehr (2013), a good educator must have a profound comprehension of their students' aptitudes and constraints in order to successfully include them in the examination of consequential matters, such as the phenomenon of global warming. This shows a dedication to fostering not just domain-specific expertise but also moral and cognitive qualities.

The statement made by Seon-Mi on the responsibility of teachers to act as moral agents and impart trustworthy knowledge highlights the diverse and complex nature of the educator's job. An exemplary educator assumes the duty of not just transmitting information in their field of competence, but also instilling a dedication to ethical values and the pursuit of intellectual growth. The pedagogical method described above reflects the attributes and principles that characterise an exemplary educator, embracing the transmission of information as well as the cultivation of personal virtues.

> I have made up my mind and decided to express chemistry as a concept which helps improve our life standards. In other words, 'chemistry class should make our life better and provide reliable knowledge'. I think having or obtaining a good range of scientific literacy allows students to read scientific issues in a more logical way rather than just reading the situation without critical thinking. For example. If fake news relating to health or science is launched in the social media, we should be able to do cross-checking. For example, in South Korea we had an issue to do with 'Radon bed mattress'. As you know, radon is a naturally occurring radioactive element. It is known that it is harmful for the human body. For example, how much radon should a bed mattress contain? (Seon-Mi, October 2019)

The excerpt from Seon-Mi echoes the idea that science education has moral value because it teaches us where we get the information we need to make ethical decisions. (Rudolph, 2020). Seon-Mi showed that there is a close connection between intellectual virtues and moral virtues. She takes radon as an example to indicate that without understanding of the moral purpose of science education, teachers cannot contribute to students' intellectual character growth. The teacher as a great creates an environment where students seek to attain reliable knowledge through intellectual actions. The findings from the interviews coupled with the findings from the focus group discussions enabled me to investigate how those intellectual and moral virtues contribute to human flourishing and to the raising of responsible citizens. When teachers were asked in the focus groups: 'What is the motivation behind teaching science?', Sin-Hyun mentioned the importance of raising responsible citizens:

> As time goes by, I have realised that my role as a teacher should be to raise students who protect the environment that they live in, gain wise decision-making ability and have logical and analytical thinking skills. Therefore, teaching chemistry comes second for me. I realised citizenship education is more important than anything else. I want to fill my students with the knowledge that is necessary for living and analysing and critiquing that knowledge. I do not want to overload information on my students. Me, as a teacher, I am not perfect. I might be mistaken so what I want from my students is to learn the knowledge that I have a lack of (Sin-Hyun, October 2019, Focus group 3).

In focus group 4, Soo-Gang indicated that the purpose of teaching any subject should not be getting high scores. Rather, teaching should contribute to students' wise decision-making.

> Students in Korea have a shortage of community, of being awareness, because students focus solely on getting into university. That is why they are just confining themselves to study for exams and learning knowledge for exams. Therefore, what I think is, this results in undermining students' perspective and horizons and ends up with producing narrow-minded citizens. We are good at tests and getting high scores,

but education is not all about getting high scores. Education is a process to make students insightful decision-makers. Getting a high score or degree should not be an end (Soo-Gang, October 2019 Focus group 4).

This position was supported by Su-Nam from focus group 2. She said:

Student's academic achievement is important, but it does not mean everyone who has a good score keeps living a good life. If we think about keeping a good life, it is not related to how intelligent you are or how the high grade you have are; it is a matter of adapting to the environment in which you live, making the right decision at the right time (Su-Nam, September, Focus group 2).

In his interview, Sang-Cheol quoted a line from 'Teacher's Prayer', a poem written by a Korean literature teacher for all teachers.

I would like to remind you of a verse from 교사의 기도 which is translated into English as 'Teacher's Prayer'. The poet said, 'Raise birds to let them fly'. So as a teacher, I would like my students to gain critical perspective and be insightful decision-makers; then I think they can adapt wherever they go (Sang-Cheol, October 2019).

It was found that the PD activities raised awareness of some societal issues, which enabled teachers to question the importance of civic and moral virtues in the teaching of science teaching. At a PD session held on 22 October 2019 in South Korea, Si-Nan gave a presentation which was designed to raise awareness about 'changes on Earth'. His presentation focused on changes in South Korea and other regions. He first distributed a handout and then explained that between 29 May 2019 and 20 August 2019 his high school students had completed a project entitled, *The Earth is suffering from global warming/climate change: A case study with high school students' featuring materials from Twitter, statistical information, and YouTube videos*. No hands-on activities were performed in this PD session. Figure 5.24 shows Si-Nan's PD session structure.

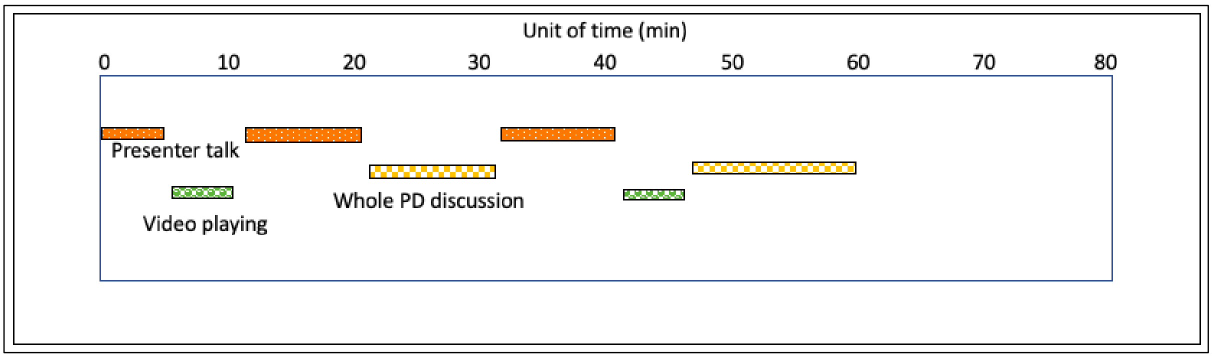


Figure 5. 24 Si-Nan’s PD session structure

Although the presenter did not provide the teachers with any hands-on activities, he raised awareness of global warming and its impacts on the Earth. He showed a video from Greta Thunberg, who is an environmental activist (see Figure 5.25). She has raised awareness on climate crises and asked for world leaders to take immediate action on it. This presentation was important because it encouraged thinking carefully about the connection between the moral virtues of teaching and what science is all about. The presentation gave insight into how important it is to take individual or collaborative moral action to generate reliable knowledge and truth for the public sphere.

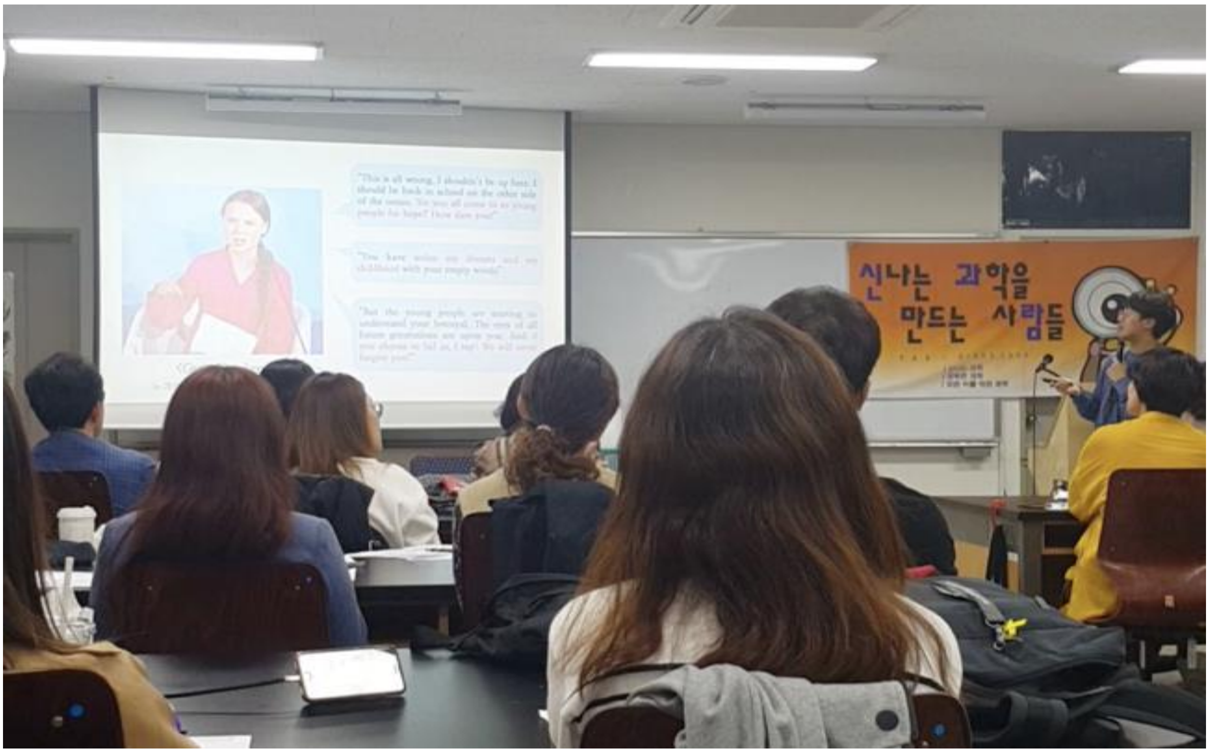


Figure 5. 25 A picture from Si-Nan’s PD session

To sum up, as explained in previous sections, teachers who can be called great supported students' moral, intellectual, civic, and performance virtues using high-quality instructions. Students who are taught by those teachers tended to question knowledge and whether the information provided by their teachers is true or not. One of the qualities that makes a teacher great is that connection between and within virtues. For example, gaining wisdom and intellectual virtues alone do not contribute to great teachers. Great teachers should also have moral virtues.

5.4.4 Professional behaviour and behaviour management

As emerged from the document analysis teachers in high-achieving countries paid attention to their professional behaviour, which comes through reflection and motivation. When Se-Hoon was asked about his beliefs about teaching chemistry and science, he responded:

> I could divide [them] into two before and after the PhD. Before I started my PhD, I used to think that I need to focus only on chemistry CK. Students tended not to choose science subjects because they find chemistry and physics difficult and boring, although I was trying to do my best to get students engaged with science. Then after I got started on my PhD, I tried to find an answer the question "who am I? and why do I need to teach chemistry?" So, now it is important to teach them chemistry but more importantly human education or whole-person education; growth of students should be provided. We have to help students' growth. Not only subject but also body, mind, character everything. Hence, as teachers what we need to do is help students' growth as a human (Se-Hoon, October 2019).

The excerpt above indicates that Se-Hoon thinks science should contribute to students' whole development. He is reflective on his development. His philosophy about teaching changed after he had started his PhD. In his interview, Sang-Woo explained how PD in informal settings contributed to his knowledge and other qualities:

> I even attended windsurfing, scuba diving training courses. It helps a lot to explain better when I use my experience that I gained through club activities and training courses in light of science. In the case of scuba diving, I can take students to environmental clean-up activities or get them to watch fishes. When you do windsurfing you can also think about how the power of the wind helps moving forward while feeling the wind. So, I just make everything related to physics. When I attend an activity, I just try to combine the things that I learned in the PD with my hobbies like scuba diving, cycling etc (Sang-Woo, October 2019).

The excerpt above indicates that Sang-Woo makes other activities relevant while teaching physics. He also raises awareness of societal issues by taking his students into nature. He links his hobbies to teaching. Both teachers showed a professional behaviour to motivate themselves to teach their subjects.

5.4.5 Conceptualisations of great teachers

An alternative position was described in South Korea. Teachers mention ‘love’, ‘affection’, ‘passion’, and ‘interest’ towards students and the subject they teach as vital to becoming a great teacher. They described themselves as *lifelong learners*, who influence students intellectually and morally. In her interview, Seon-Mi was asked to describe what makes a teacher great; she said:

> For me, it is definitely passion. This passion comes from love and interest in students. If you have passion about teaching, then you just want to do something for them. If you have love and affection, then it leads you to make an effort to do something which makes a difference in students’ lives. I think teachers who have skills and techniques might have difficulty in making passion but those who have passion tend to build and develop skills and techniques for teaching their subject better (Seon-Mi, October 2019).

The excerpt from Seon-Mi indicated that passion empowers teachers to develop the skills they need for teaching. In line with Seon-Mi, Benekos (2016) explained what great teacher need. He assumed that insight, thought, and enthusiasm are necessary for a great teacher since teaching requires action that connects the teacher and the student. Passion for teaching incorporates scaffolding students’ learning, cultivating students’ intellectual and moral virtues, and caring about their learning. In line with Seon-Mi, Se-Hoon also thought that passion and professionalism play a significant role in enhancing teachers’ professional knowledge and skills.

> Teachers should accept their work as part of their life style. After accepting teaching as a life-time goal and life-time philosophy, then they can develop their teaching skills and professional knowledge, so firstly they should love what they are doing and be passionate about learning and development. Second, they should love students. After finishing their work every day, they should think about their teaching; they should have self-judgement. What is more, after the class, teachers should keep writing a diary about what they have taught and given to students (Se-Hoon, October 2019).

From Se-Hoon’s perspective, passion enabled him to develop skills and knowledge and to go the extra mile for his students. Fried (1995) narrowed down passion for teaching into three categories. He thought that teachers may have passion for developing events in the world, for knowledge, or for students. When Su-Mi was asked the same question, she said:

> Love and affection as well as interest towards students and good communication with students. Those are I think what makes teachers great. Teachers also should be good listeners when students come to ask about something. On the one hand, teachers should approach students objectively, but they also approach them with compassion. Teachers should get students to feel, like, there is someone over there for me (Su-Mi, October 2019).

This passage from Su-Mi indicates that epistemic characters of teachers such as curiosity, open-mindedness, and critical thinking are important to deliver their practice. However, Su-Mi thinks that emotions like love and affection along with interest make a teacher great. Those character traits might be considered as hidden concepts which motivate teachers to develop and go the extra mile for students and society. Sang-Cheol thought make a teacher great. He replied:

> It should start with ‘interest’ and ‘love’ towards students. It is basic. From the academic success point of view, you can improve teaching technique and skills as well as expertise knowledge on your own. It is also possible to improve those parts by attending PD. On the other hand, having a good heart towards students is really important for their character education. Having ‘love’ and ‘affection’ are more important than having a really good subject matter knowledge or something. On this point, if the teacher thinks teaching is a job, of course I can respect his decision, but the outcome will be different. So, for me, the starting point is basically to have affection for students. It makes a teacher great or different than others (Sang-Cheol, October 2019).

The quotation shows that Sang-Cheol highlights qualities relating to passion, wisdom, and professional behaviour that make teachers great, followed by qualities relating to their knowledge. Qualities such as passion, wisdom, and professional behaviour could be considered as professional virtues which contribute to practical wisdom. Teachers in South Korea seek to cultivate students’ intellectual virtues such as curiosity, critical thinking, critical judgement, and wise decision-making. Cultivating intellectual virtues not only makes students scientifically literate, but also promotes students’ practical wisdom. In this respect, Baehr (2013) focused on the importance of intellectual characters and virtues. The ideas of intellectual character and intellectual virtue are highly helpful, as intellectual virtues may be understood as the individual traits of a person who is committed to learning throughout their lifetime. (Baehr, 2013). South Korean teachers in general and Seon-Mi, So-Yeon, Si-Eun, and Su-Mi in particular paid attention to raising awareness of societal issues happening in South Korea. To be able to judge those issues critically, intellectual virtues should be gained. Then students might differentiate between right knowledge and false knowledge in daily life (Sharon & Baram-Tsabari, 2020). The more teachers attend PD, the greater the insight they gain about societal issues because every teacher brings issues and problems to PD.

5.4.6 Teachers' professional development in context

All four nations provided teachers with PD. Teachers in South Korea found it beneficial to attend face-to-face generic learning communities in which teachers with contrasting subject expertise come together. When Seon-Mi was asked about ways of updating knowledge of science, she pointed out that

> Somehow, as you know, chemistry is related to other sciences. So, learning from science teachers who teach biology and physics provides me with better understanding of what science means. I would say that although generic PD courses do not contribute to my chemistry CK, those courses definitely help me to improve my PCK.

In South Korea, teachers generally do not teach outside of their specialist area (see detailed information on teacher education system in South Korea in section 3.6.2), which leads teachers to attend PD relating to generic PD. They are more willing to attend PD programmes which develop their pedagogy and virtues. Si-Eun found it beneficial to come together with social science teachers. She said:

> Not only do I come together with chemistry teachers, I also come together with arts, music, literature, and languages teachers because I believe that teaching requires a piece of knowledge, a piece of voice, a piece of art. I find it really important to look charismatic in front of students. So, I would say that I am quite active and have gained different sorts of experience from attending with generic PD rather than subject-specific (Si-Eun, October 2019).

Generic PD programmes give teachers new insight into how to develop their skills relating to how to teach. In the community-based PD (Shingwaram) that I attended in South Korea, teachers from different subject specialisms and different stages (K1 to K5) shared their experience and instructions when teaching science to different age groups. So-Yeon, who attended the lesson study groups, shared her experience in her semi-structured interview. So-Yeon said that

> Three other science teachers and I established a study group to make some difficult contents easier for students. One of them and I teach in high schools and other two teach in elementary and middle school. In terms of chemistry CK, I think I am confident about it but in that group, we are doing brainstorming about finding the best and easiest ways how deliver knowledge to students. For example, if I deliver specific and detailed or technical information, then my group members ask me why do you need to deliver those knowledges. Furthermore, they also ask me if you deliver those knowledges, what would be your assessment criteria. They examine me objectively. To reshape my ideas and thoughts before I get into the class, they observe me, correct me, guide me, and give feedback to me. In terms of PK, elementary and middle school teachers have various instructions to deliver knowledge (So-Yeon, October 2019).

This quotation from So-Yeon indicated that teachers who share common goals in a lesson study group encourage each other to develop better contents for students. Collaboration within a community enables teachers to gain different perspectives. Many teachers in this study also had a passion to develop themselves through social media and attending seminars and workshops. Shingwaram is a generic PD activity which supported teachers with resources and materials. Not only do teachers learn new instructional strategies, which support their practice, but they also share their experience, listen to different voices, dialogue with each other, and learn from each other.

The majority of the teachers indicated in their interview that they follow at least one PD constantly. The reason is twofold. First, PD is mandatory. Every teacher should attend at least 60 hours of PD in a year. However, teachers in the study highlighted that they attend more than 60 hours a year. Second, teachers in South Korea have passion, affection, and a love of learning. Therefore, they attend lots of programmes. Figure 5.26 below shows Korean teachers' PD provision.

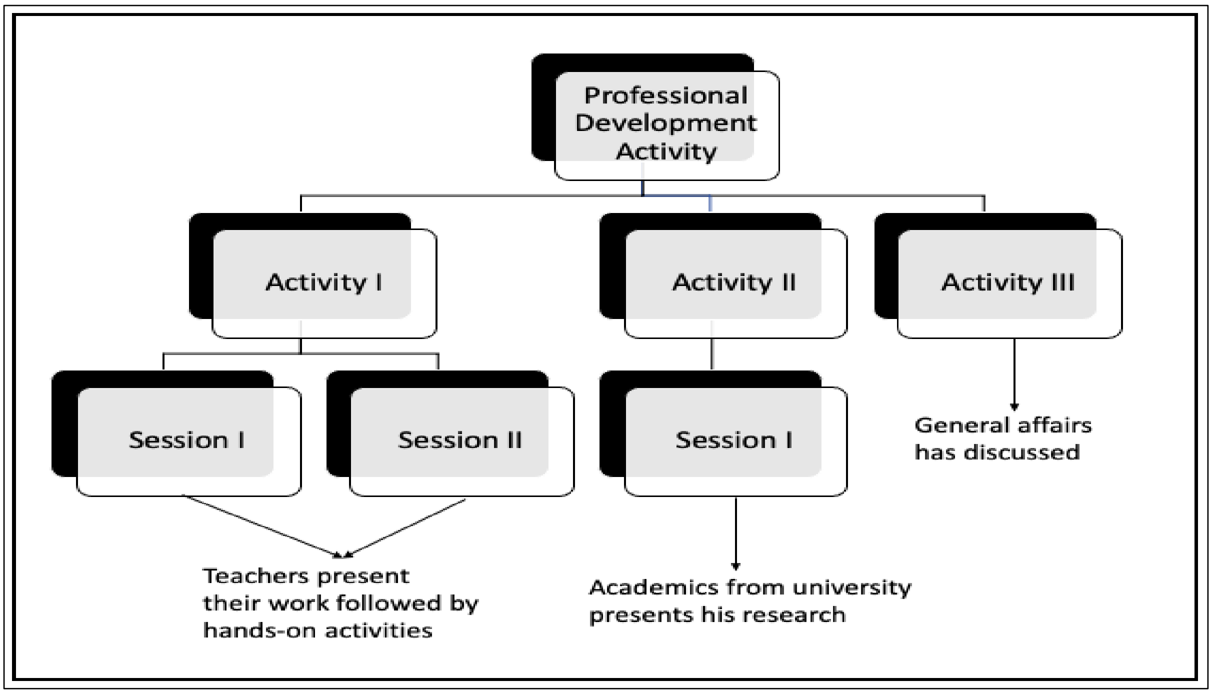


Figure 5. 26 Outlook of PD activity in South Korea

Overall, interviews and observations in Shingwaram (CoP) indicated that character was emphasised in PD sessions. The emphasis placed on personality traits such as self-confidence, which is a performance virtue. As teachers in CoP presented their work and instructional strategies, they gain more self-confidence. Some sessions also leave space for reflection on moral virtues and raise awareness about some societal issues such as global warming, radioactive pollution that teachers ne to be aware. Providing teachers with sessions with a focus on cultivating character virtues resulted in developing teaching practice. Experienced teachers and master teachers in CoP also provide novice teachers with good mentoring. They become a moral exemplar who aspires to be for less experienced teachers.

5.5 Case IV: Turkey

The semi-structured interviews (see Section 4.10.1), classroom observations (see Section 4.10.2) were designed to capture similarities and differences regarding perceptions of great teacher and great teaching among chemistry teachers of 14 to 18-year-old students in Turkey. Based on thematic analysis, six distinct themes emerged. Each of these is discussed in turn. The next subsection discusses evidence relating to CoP from all the data.

5.5.1 Community of practice (CoP)

Teachers in Turkey have fewer opportunities to attend community-based PD. The reasons for this being a case in Turkey are explained in Chapter 1. Some teachers, on the other hand, are willing to participate in PD throughout their careers. Turgut is a chemistry teacher with over 30 years' teaching experience. He has attended a lot of PD, which supports his PCK. When Turgut was asked 'In what ways has the PD enabled you to update your knowledge of science?', Turgut answered as follows:

> We gain different points of view from other colleagues in the PD. We had a conversation and interaction as well as mutual effect with each other. In the PD, recent changes, up-to-date information and recent developments in chemistry are provided to us. Interaction between teachers is the most essential part of the PD. I go there to learn how other teachers teach different subjects to students. I learn from them, and they might learn from me. For example, once I attended the course related to laboratory in chemistry; I gained lots of knowledge about how to organise and design a laboratory and how to do better experiments. I would say, based on that PD, I designed four different chemistry laboratories in four different schools where I worked (Turgut, February 2020).

The excerpt shows that subject-specific PD enabled Turgut to improve his CK and skills relating to how to carry out better experiments in chemistry. The analysis of the interview indicated that PD helps in developing his meaning-making process. He thinks a teacher's office is also a part of PD. In Turkey, there is a common room (see Figure 5.27) where all teachers come together at break time. Turgut explains how he benefits from coming together with colleagues at break time:

Figure 5. 27 Teachers' office in Turgut's school

> In this school we have 30 teachers who come from different backgrounds, but have the same goal. We have 10-minute breaks before starting the lessons. Even though it is very little time, I refresh myself with meeting my other teacher friends. We have a very good synergy in the teachers' room. Coming together in the teachers' room is very good in terms of refreshing myself, motivation and asking questions of my colleagues. I can get help from mathematics teachers, if I have a difficulty in solving some mathematical equation. For example, in the previous curriculum I had to keep in touch with and collaborate with biology teachers because there were lots of subjects relating to biology which were transferred to chemistry. However, as chemistry teachers we collaborated together in a community and discussed what we should be able to do. Before the curriculum was redesigned, I kept in touch with physics and biology teachers to get to know about quantum and energy in living creatures, respectively. For example, I had learnt about the digestion of fats and carbohydrates, but as time went by, I forgot it and then I booked an appointment with one of the biology teachers after school and wanted her to explain some vague points in my mind to make them clearer.

The quotation above shows that Turgut has passion and is willing to update himself and exchange knowledge with others. Turgut thinks of the teachers' room as a special place where teachers can motivate each other and develop their dialogue to create an authentic atmosphere. This is how he develops himself through PD. Tolga is a chemistry teacher with 15 years' teaching experience. Tolga has attended in-service teacher training provided by the MoNE. Those trainings are mandatory. When he was interviewed, he explained what kinds of training courses he attended:

> I have attended a course called 'modern approaches to science education'. It was a 5-day course. I also attended seminars every year, which are held twice a year. Some of them give you a certificate but some do not. They are a 75-hour course or more than 75 hours. I attended a course which was about how to use a smart board in the classroom. It took 76 hours. There was also an 8-hour course related to interactive board. Those courses are held in two ways: local and national. The local one takes place in Konya and the national one is organised by the MoNE. You apply to those courses but sometimes you cannot be selected because participants are selected randomly (Tolga, February 2020).

The excerpt from Tolga indicates that training courses in Turkey are not based on teachers' needs. Since teachers are randomly selected for courses, teachers' needs are not considered to be a priority. When asked how training courses helped to update his knowledge of science, he said:

> I met other colleagues there, so it was quite good for me. We exchanged knowledge. Additionally, when I attended a course in Yalova (a city located northwest of Turkey), we also created a WhatsApp group among science teachers. We keep in touch. It is open for debate how effective the programme itself was but groups that we created in those programmes were quite effective (Tolga, February 2020).

The excerpt shows that Tolga was not satisfied with the content of the in-service training course. However, the course provided him with the opportunity to meet their colleagues who came from other cities in Turkey. The training courses in Turkey in general take 1 day. In-service training in the beginning and at the end of semesters takes 5 days. Otherwise, there is no regular PD. Tolga stated his opinion in the quotation below:

> I do not attend any regular PD and indeed I haven't heard of that kind of regular course nationwide, though. Based on the situation, we try to update ourselves. We do not get any support from the MoNE (Tolga, February 2020).

The quotation from Tolga explains the reason why he does not get benefits from PD. There is no continuity in the courses that Turgut attended and so resulted in limited opportunities to reflect his practice. Tuba is a chemistry teacher who studied pure chemistry. She made up her mind to be a teacher after she had completed her master's degree in organic chemistry. She was asked about which PD activities and experiences supported her work as a teacher. She replied:

> Apart from compulsory in-service training courses, I rarely attended PD courses. I have got self-motivation. I motivate myself about what I need to do. I try to follow new trends. When I was in Afyon (Anatolian city located in the middle part of Turkey), I was a team member of "Let's generate engineer girls" project. That project was awarded as the best project in Afyon. So, I was so happy. I attended a couple of seminars in technology field. I attended course related to STEM education and technology. I also attended a day-long robotic coding course (Tuba, February 2020).

The excerpt shows that Tuba is a self-motivated teacher who takes care of her PD. It is difficult to say that there is a strong CoP in Turkey. Therefore, their training activities did not support shared repertoire, shared value, or mutual engagement. Therefore, they have not had the opportunity to engage in reflective practice.

5.5.2 Pedagogical content knowledge (PCK)

When teachers in Turkey were asked what kind of instructional strategies they used, Tamer explained how he teaches chemistry in his classroom:

> If you just teach theory, students memorise it and forget it. if I reinforce theory with the experiment, students grasp some difficult concepts easier. I experienced it. If students do not touch, feel or see, it does not make sense in students' cognition even if you teach theoretical knowledge well. (…) Students memorise the whole periodic table but when I ask about elements and their history or who discovered where we can use them etc. they do not know it. They just memorise; knowledge that they acquire cannot go beyond memorisation. In this regard, teachers' PCK is quite important to get students to gain different perspectives. Instead of teaching the ordinary periodic table, I should set them challenges, preparing a different periodic table based on a historical point of view, elements' density, and so on and so forth. (Tamer, March 2020)

The excerpt shows that Tamer uses strategies to teach the periodic table to students. He also believes theory should be supported by experiments. However, some schools in Turkey do not have a laboratory. To identify components of PCK and how they influence teachers' practice, classroom observations were performed. Three Turkish teachers i.e., Türkan, Tolga, and Turgut were observed while they were teaching organs in a biology class and covalent bonding and dipole interactions in chemistry classes, respectively. While Türkan used experiments and inquiry-based teaching to explain organs in her biology class, Tolga and Turgut used didactic strategies to explain covalent bonding and dipole interactions. For example, Turkan encouraged students to participate actively while explaining organs in her biology class. She had an hour-long class in which to show two experiments. The experiment structure for Türkan's class can be seen in Figure 5.28.

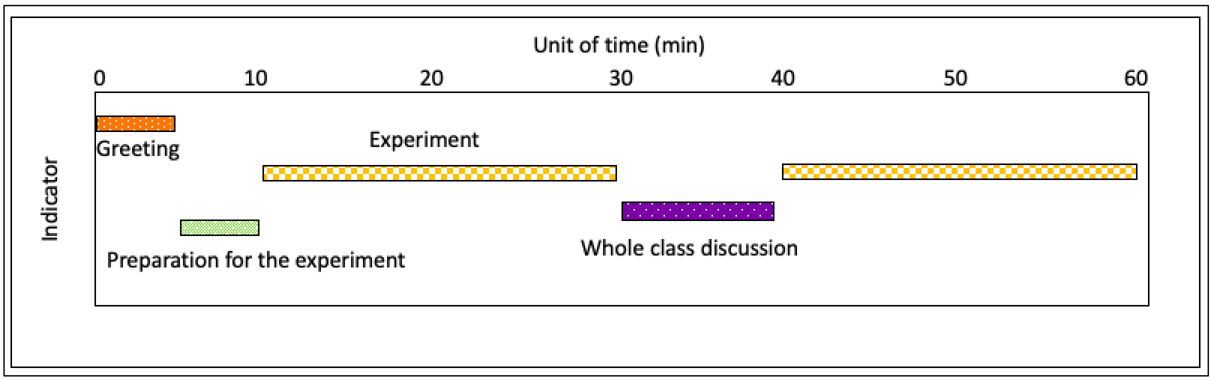


Figure 5. 28 Türkan's laboratory structure

She brought lungs and a heart to show the lungs' and heart's segments. She said she had bought them from a butcher. She did not want to show a YouTube video to introduce the topic. Instead, she used direct demonstration, as she believed that hands-on activities help students understand a topic better. She wanted to visualise and prepare an active learning environment for her students. The excerpt from Türkan's class below shows how she engaged her students in the classroom.

> **Türkan:** Today, we will have a close look at the internal organs of a mammal. First, I would like to show you what happens in the lungs when we inhale and exhale. Timuçin and Talat (students names), do you mind could you coming here and helping me? I would like you to blow out from here (see Figure 5.29) and then I will show you what happens.
>
> **Students:** Yes, of course teacher.
>
> **Türkan:** As you see, When Talat blows out, the lungs are getting bigger and then come back to normal. When the lungs are getting bigger, we can see the lobes better. Now let's remember what happens when you inhale. First, air enters the lungs. The muscles between your ribs tighten. This allows space in your chest. When the diaphragm muscle tightens, it becomes flat. So, what happens, when it becomes flat?
>
> **Students:** The volume of the lungs enlarges
>
> **Türkan:** Yes excellent. What about the pressure in the lungs?
>
> **Students:** Decreases. Because if the volume increases, then pressure decreases.

Türkan: Definitely. When atmosphere pressure is higher than internal pressure, air goes down to the lungs passing through the trachea…

Figure 5. 29 Türkan's experiment to show how the lungs work

In her interview, Türkan pointed out the importance of active learning:

> Science without experiment is nothing. There is a saying: "If I hear something, I tend to forget it, If I see something, I can remember it, but if I do it, I learn it. If you fail to engage in student active learning, you cannot teach the subject. For example, today I taught "root system in plants", I asked my students to bring a carrot. We ate the cortex then the remaining part of it called the central stele so they cannot forget it anymore.

The excerpts from Türkan's interview and classroom observation indicated that doing experiments and engaging students play an important role in teaching the topics in the science classroom. Türkan used demonstration and visualisation in her classroom as instructional strategies. In contrast, Tolga used didactic teaching when he explained metallic bonding. His lesson structure appears in Figure 5.30. From beginning to end, Tolga dominated the class. He did not use technological tools to demonstrate or visualise metallic bonding.

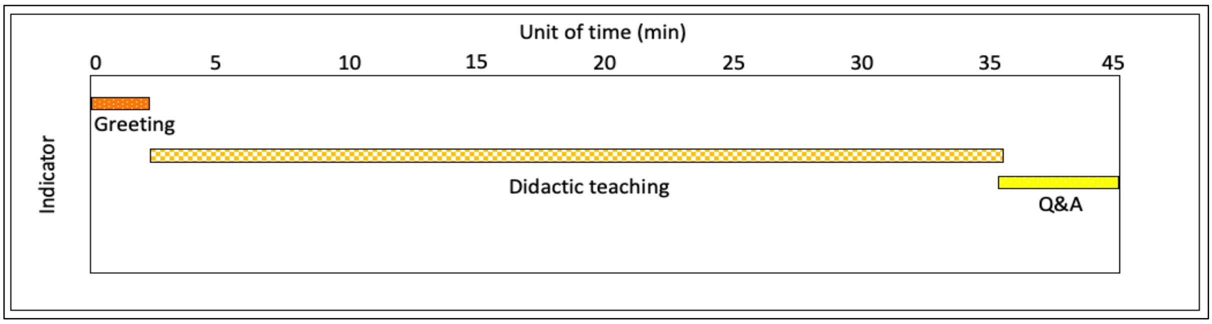


Figure 5. 30 Tolga's classroom structure

However, he explained how characteristics of metal atoms impact on our daily life. The excerpt below shows how Tolga associated the topic with daily life:

> **Tolga:** So, what is the principle of photocell light? What I want is that the streetlights turn on and off automatically. When it gets dark, they are on and when it gets light, they are off. What I need to do is to put here a photocell. When I put a photocell in this circuit, plus and minus charges flow through this way instead of that way; it means electrons choose the easiest way to complete the circuit (short circuit). When the photoelectric sensor emits the light, a short circuit happens and light is off. It is same for sink faucet and doors etc. This is because of the eagerness of electrons at the outmost level.
>
> Let's look at another characteristic of metallic bonding. Metallic bond is strong. Why is it so? Because nuclei are always interacting with electrons as they are everywhere. We also know that metals conduct electricity. Why is it so? It is because of delocalised electrons. What I am saying is when you supply energy from here, it reaches anywhere that the metal is available. Metals also conduct heat because the electrons in metal are delocalised electrons and are free moving electrons, so when they gain energy (heat) they vibrate more quickly and can move around. This means that they can pass on the energy more quickly. As you know, ionic compounds are easily broken. Ionic crystals are hard because of tight packing lattices, say, the positive and negative ions are strongly attached among themselves. So, if mechanical pressure is applied to an ionic crystal, then ions of similar charges may be forced to get closer to each other. Now, by doing so, the electrostatic repulsion can be enough to split or disorient completely the lattice infrastructure, thus imparting the brittle character. However, metals are not broken. When you hit metals, the electrons are still everywhere and metals keep their structure. You can bend them because everywhere is a sort of electron sea. Therefore, nuclei never push each other; they pull each other because plus and minus charges have come together. So, they will not be broken but they can be bent and shaped.

The excerpt shows that, although Tolga used didactic teaching, he gave examples relating to daily life to make sense of the knowledge. As Tolga highlighted, making chemistry relevant is important to engage students. Making context relevant engages students' interest in the classroom. Irit in Israle similarly pointed out the importance of relevant in chemistry. When asked in her interview: 'What would you say your professional beliefs about teaching chemistry are', Irit said:

> Irit: It needs to be relevant. Nowadays, students do not like difficult things. So, it is important to make chemistry topics fun and interesting make them relevant. Chemistry is important; it explains what happens around us so the relevance is really important.

Irit's opinion here was supported by Tolga's classroom teaching, as he too believed that making chemistry topics relevant plays a significant role in making understanding of abstract topics easier. 'Making science learning relevant both to the learner personally and to the society in which he or she lives should be one of the key goals of science education' (Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). Tolga also had a sense of humour in the classroom. When he was explaining about characteristics of metal atoms, he made his students laugh, as shown below:

> Tolga: Now, I would like to explain how those characteristics of metal atoms at the outmost level impact on our life. Actually, it brings about some interesting cases. You will ask 'Like what?' You go to the sink and get your hands closer to tap, then water starts to come and you get your hands back from the tap then the water stops coming. Before you come to door, the door is opened and after you pass the door, the door is closed… but the worst thing is when you go to the toilet, if it is a photocell lamp, you always shake your hand ☺

The statement above made the students laugh. Although Turgut used didactic teaching, he also interacted with his students. In his interview, Tolga was asked what qualities make a teacher great; he said:

> Tolga: When I teach a topic, I look back at my high school years. And ask myself when I was in high school, what sort of teacher made me bored? It was boring to listen to teachers who explained the topic monotonously and had not got a sense of humour. Therefore, I think sense of humour is a quality that makes great. Therefore, I put in a couple of jokes to make my students not bored while teaching.

Similarly, Turgut used didactic teaching to explain dipole interaction. His lesson structure is shown in Figure 5.31.

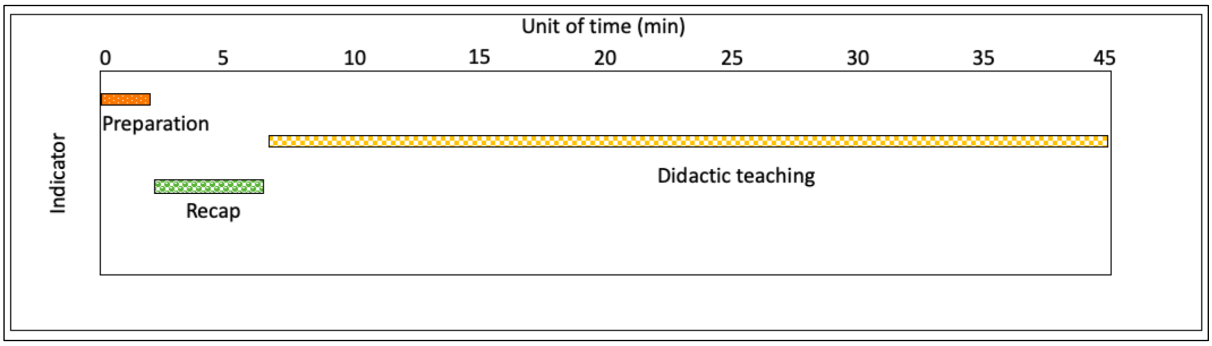


Figure 5. 31 Turgut's classroom teaching structure

Turgut prepared his students for the chemistry class. In the first 2 minutes, he wanted students to ready themselves mentally for the chemistry class. In his interview, Turgut explained how he readies his students for class.

> Turgut: As soon as I get into the classroom, I always change students' mode to chemistry. I prepare them mentally first. I want them to leave everything behind. I want them to focus solely on chemistry. I have a slogan. It is 'Everybody please turn into chemistry mode'. Making them ready to learn chemistry is important.

The excerpt from Turgut indicated that Turgut seeks to prepare a classroom where students are emotionally, mentally, and physically ready to learn. Before he started teaching the topic, he interacted with the students. Once they were ready for the class, he started teaching chemistry. He used a PowerPoint presentation to show weak interaction between atoms (see Figure 5.32).

Figure 5. 32 Turgut's PowerPoint presentation

Turgut highlighted text in different colours such as red, blue, and green. Red for example indicated that that part is very important. Green indicated that it is essential to learn that part. Turgut captured students' attention using visualisation. Turgut preferred not to play a video to show the difference between weak interactions. Instead, he used his own presentation. He did not use sources from the internet. He said he prepared everything by himself. Overall, teachers in Turkey, as did their counterparts in Israel and South Korea, used different ways to teach their subjects. Türkan believed hands-on activities help students understand a topic. While she was explaining organs and the heart, she used a cow's lung to show her students bronchi, arteries, and veins. Turgut and Tolga delivered their knowledge to students using didactic approaches.

5.5.3 Professional Beliefs and Virtues (PB&V)

When it comes to professional beliefs about teaching chemistry, Turgut believes learning chemistry should help students to gain scientific literacy skills. He said:

> Being a chemistry teacher, I have different points of view, even about drinking water as compared to those teachers who teach history or math. Chemistry used to be a very numerical class in Turkey. For example, students, develop some formula for ideal gas equation (PV= nRT) (**P**aran **V**arsa **N**e **R**aha**T**) to keep in mind. Some teachers they also use some formula, which I think make students get away from scientific literacy. It also kills that ability too. From my point of view, getting students to memorise those formulas and equations makes the understanding of chemistry difficult even though it works in exams. Chemistry is not about putting numbers in the equation and finding the correct answer. It is about asking "why" because it does not show that you grasp the topic when you put numbers into equations and find the answer. What should matter is to get away from theory and raise questions like "why does it happen?" If you just have students memorise formulas, then they will not learn anything (Turgut, February 2020).

The excerpt above indicates that Turgut would like students to question knowledge instead of memorising that knowledge. Turgut gives ideal gas equation as an example. Some teachers create formulas for their students to memorise, but what Turgut highlights is that students should know what P, V, n, R and T refer to in the equation. Turgut wishes students to critique what they learned. This approach to teaching helps students to be wise decision-makers and critical thinkers. However, the exam system in Turkey leads teachers to teach knowledge for exams. Therefore, teachers in the classroom just deliver the knowledge which is necessary for the exam. Observations of Tolga's and Turgut's classes showed that they just delivered the knowledge relating to the exam and solved questions which students might possibly come across in the exam.

For example, Tuba said in her initial interview that although she asked for chemistry lab for 2 years, nobody listened to her. Moreover, some schools have laboratories that are not used because teachers' priority is to deliver theory first. In the university entrance examination students are asked about only theoretical knowledge through multiple choice questions. In addition to those beliefs about teaching chemistry, teachers' personal beliefs about education overlaps teaching chemistry. Some teachers pointed out that teaching chemistry comes second. For example, Turgut explained that education should aim to help students to gain moral characters. When he was asked what the most significant personal value that he communicates to students was, he answered:

> I value national and moral things the most. I think those values both national and moral should be gained by students. Science, it does not change nation to nation. Each nation teaches the same chemistry topics, like the periodic table is the periodic table wherever you go. However, each nation approaches differently its chemistry teaching based on their tradition, moral settings, etc. So, I want my students to pay attention, saying whatever you do, just do your best and gain work ethics no matter what you are doing (Turgut, February 2020).

The excerpt shows that Turgut thinks of a teacher is a role model and exemplary person who is responsible for cultivating moral and national values. The moral purpose of education, which aims at building character and personal virtues, should always be remembered in science education. The competency-based approach in knowledge-driven economies puts emphasis on the importance of knowledge and skills that people should have. Less emphasis is put into cultivating moral virtues in education, which results in students who are not critically engaged with science or enjoying science. When Tuba was asked if there had been any changes or development in her beliefs during her career, she explained:

> I think it changes as time goes by. At the beginning of my career, I focused solely on students' academic achievement. I used to think that as a teacher I had to solve all questions. As such, I just paid attention to academic achievement. I worked in a couple of different schools. As I get older or as I get more experience, I care about students more. I started to recognise them as a person who can have problems like us. As time went by, I prioritised students' social, psychological, and intellectual development. Of course, I do not ignore academic achievement. Chemistry is I try to get them to gain knowledge, but I also aim at gaining

them some other important values like helping each other, collaboration, let them do volunteer work (Tuba, February 2020).

The excerpt from Tuba indicates that experience has made her a more student-oriented teacher who cares about her students as human beings. The change in her beliefs had an influence on what she focuses on mainly while teaching science. Tuba as a teacher ignores neither students’ academic achievement nor their character development. Campbell (2008) in her review study claimed that teachers' moral roles are inextricably linked to their professional practice. Teachers' activities were reinforced by their etical value and sensitivity to students' progress and learning, which stemmed from their beliefs and professional behaviour. When Tülin and Tezcan were asked what personal goals are most important for their work as a teacher, they paid attention to students’ moral education. Tülin said:

I pay attention to students’ personal and character development because I see myself as a moral agent in addition to teacher. Sometimes, teaching chemistry comes second. For example, I try to raise awareness about global warming by explaining the chemistry behind it. I explain why we need to fight against global warming. I try to update them by mentioning social issues like water shortage, how to make pure drinking water from the sea by applying electrolysis. Another issue is recycling, I try to explain the importance of it. Those are a couple of issues that we really bear in mind. My goal is to make students aware about the environment where we live. First, we need to learn to live as a society; after that, individuals make a difference. We need to get students to gain social norms and moral rules, ethical considerations when we can teach something (Tülin, February 2020).

Tülin’s comments were also supported by Tezcan. She also thinks of herself as a moral exemplar. She said:

What I pay attention to the most is respect and moral principles. Moral education comes first; thereafter I focus on the subject and teach chemistry. If we raise students who keep moral principle, then I think providing students with SK is getting easier. Unfortunately, we focus much more on education then moral training ends up lagging behind. The result is they become a good engineer or doctor, but they might have problems with being a human being. Students might not be interested in science, s/he might have ability on arts and music or literature. Therefore, I do not get angry about why you do not understand chemistry or why you are not interested in chemistry. However, I cannot put up with disrespectful behaviour (Tezcan, February 2020).

The quotations from both Tülin and Tezcan indicate that moral actions in the classroom provide teachers with the opportunity to create a classroom where students gain moral character. These moral characters lead students to think critically about societal issues such global warming, water putridity, etc.

5.5.4 Professional behaviour and behaviour management

In his interview, Turgut was asked to describe what makes a teacher great. The quotation below shows his response:

> First, a teacher is a role model. In other words, he is an exemplary person. He must leave a positive impression on students. He should not look, like, untidy. He should dress smartly. First impression is always important. Second, he should use Turkish language perfectly. Whenever I get into class, I changed students' mode to chemistry with some warm-up questions. I prepare them mentally first. I want them to turn in 'chemistry mode'. When I close the door, I am not a father of two, I am not a husband of my wife, I am a chemistry teacher (Turgut, February 2020).

In line with Turgut, Türkan also found professional behaviour important to make students engage to class. She said:

> [a] Teacher should be well-disciplined. He should not be late for his class. He should be a model with his dressing and character. You should dress up smartly. First impression is always important from the students' perspective. For example, I always look in the mirror, before I enter the class to check myself [to see if] I am ready or not because if there is something unusual, then students find it funny then laugh; after that I can lose my motivation. I am also the authority there; students must respect me and I must respect them (Türkan, February 2020).

As the two excerpts indicate, visuality and behaving professionally are essential for catching students' attention. Türkan's statement showed that she represented professional behaviour, which enabled her to gain and perform respect in the classroom. Turgut reflects the importance of preparing students for learning. Behaviour management is a prerequisite for presenting professional behaviour in the classroom. Tanyeli for example said:

> I easily internalise small issues in the classroom, and I am too sensitive sometimes. I know it should not be like that, but I really need to learn how to behave professionally. Instead of judging students directly, I need to understand them, why they behave like that (Tanyeli, February 2020).

As indicated in the quotation from Tanyeli, behaviour management influences interaction between teachers and students. Professional behaviour management builds a positive classroom culture. For example, Tanyeli is easily impacted by students' behaviour in class, which might create an unsafe environment in which to ask the teacher a question.

5.5.5 Conceptualisations of great teachers

Cultivating moral virtues and raising morally and ethically responsive students are considered important qualities that make a teacher great. Turkish teachers thought students' moral and personal development comes first. Hence, teachers in Turkey can be considered as *moral exemplars*. For example, when Tanyeli was asked what personal goals were most important for her work as a teacher, she said:

> It does not matter whether you learn chemistry or not. You can learn it from somewhere, from me, from the internet or another teacher. What does matter is to have a good character and to be a good person. So, they can learn chemistry by force or different sources. We are teachers here aiming at getting learning faster. I want them to have sensibility towards some social and national issues (Tanyeli, February 2020).

The Jubilee Centre for Character and Virtues defined great teacher as one who fosters virtue and encourages ethical behaviour. The essence of the profession cannot be captured by a definition of teaching that is based exclusively on topic knowledge and teaching expertise, skill, or competence. (The Jubilee Centre for Character and Virtues, 2017). Tanyeli thinks that education should contribute to students' knowledge and character. Teachers are one of the most important agents for providing students with both. Turgut summarised why delivering knowledge is not enough:

> Actually, the biggest goal to achieve in my career is that I would like my students to turn knowledge into action and positive behaviour. I have been teaching chemistry for over 30 years. What I have recognised is that CK that I taught does not make sense unless it contributes to students' manner and behaviour. Knowledge brings success in exams, but what about real life? Education makes sense when teaching contributes to moral development of students. For example, if someone becomes a very successful business man. If s/he is doing corruption, then it is not good for society. Someone becomes a president, but s/he is doing bribery, it is also bad for the country. From this perspective, if we raise well-educated people, they contribute to the country, but if we fail to raise well-educated students, it undermines the country (Tanyeli, February 2020).

The excerpt from Turgut indicated that teachers take responsibility for raising students with good character traits which support a country as a whole. Teachers in Turkey framed their lessons based on the curriculum. They said they followed the curriculum handed down by the MoNE. However, they also highlighted that there is no character-framing education in the curriculum. Teachers therefore present their value and moral character in the classroom. Tuba gave an example of why a teacher should be a representative of moral character.

> As a teacher, I am responsible for my students' moral character growth. What I believe is that I need to be an exemplar in the class; then students can follow me. I am fair to all students in the classroom and I think all of them as an equal human being and respect them. In my class, I have students from different ethnic and religious groups like Muslims, Turk, Kurds, even Syrians and so on. It means, in the same class, I have students who value different points. If I do not behave fairly to each student, students do not learn the virtue of fairness to each other. Then it impacts on the classroom environment adversely. I need to decide precisely what all students need. Not just for particular students. Teachers' character is important for building a safe classroom followed by delivering CK (Tuba, February 2020).

Tuba indicated here that she believed that teachers in the classroom are considered moral agents and that her behaviour and attitudes towards students influence students' well-being in the classroom. Buzzelli and Jonhston (2002) indicated Teaching requires a keen understanding of the importance of one's decisions and how they affect the growth and welfare of others. Understanding a profession's moral importance helps expand teachers' professional knowledge and, in turn, broadens teachers' perspective on the understanding of that profession. This shows that teachers as a moral exemplar actually promote intellectual virtues. Virtues develop high-quality relationships and build dialogue with students, which are essential features for delivering knowledge to students and influencing teachers' PK and getting to know their students better in terms of what they need.

Overall, the findings from each teacher in Turkey indicate that great teacher is associated with being a moral exemplar. In their interviews, most teachers pointed out the importance of the moral duty of teachers. Curren (2014) noted that having people act with morally sound judgement is the ultimate goal of an Aristotelian education. Teachers like Turgut, Tolga, Tezcan, and Tülin pointed out that students who lack moral judgement tend to have poor understanding of some societal issues. Thus, teachers who show moral character in the classroom might make their students aware of those issues.

5.5.6 Teachers' professional development in context

Teachers in Turkey tend to participate in compulsory and out-of-topic in-service training, although some teachers attend relevant PD on their subject specialisms. Turkish teachers have fewer opportunities to develop knowledge, and they undertake fewer collaborative activities. This situation contributes to reducing their motivation for teaching. In Turkey, teachers are trained as a subject specialist (more information can found in chapter 3 section 3.7.2). Therefore, teachers tend to attend PD relating to PK or compulsory training courses. When Tamer was asked what PD activities supported his work as a teacher, he replied:

> I found and attended some development courses, which are not directly linked to my subject area but to some extent related to pedagogy such as assessment and education for questioning. The MoNE in Turkey generally does not provide teachers with subject-specific PD. Instead, the MoNE established an online platform where teachers share their materials, instructions, and experiments (Tamer, March 2020).

When asked the same question at interview, Tuba said:

> Apart from compulsory in-service training, I rarely attended PD activities. I am a self-motivated teacher. I motivate myself about what I need to do. I try to follow new trends. When I was in Afyon (a city in Turkey), I attended a training course relating to STEM supplied by a private organisation. It was a 5-day course lasting 30 hours. It provided participants with an active learning environment (Tuba, February 2020).

Both quotations show that both teachers are willing to develop themselves. The MoNE in Turkey does not provide teachers with PD. Instead, the MoNE provides in-service training when a new curriculum or system comes into being. This change causes teachers to go to in-service training which is either not relevant to their subject area or not related to science. In 2010, the government took an initiative to integrate computer technology into the Turkish education system. This project was called FATIH (Firsatlari Arttirma ve Teknolojiyi Iyilestirme Hareketi), which means movement to increase opportunities and technology. In their interviews, all the teachers said they attended the course relating to the FATIH project, as it was compulsory. Türkan for example said:

> The MoNE provided teachers with compulsory in-service training under the 'FATIH project', which was about the integration of technological tools in the classroom. The title of the course was "How to use interactive smart board" but I already knew how to use a computer and how to connect it to a smart board.

> I have attended a couple of other courses which were compulsory but I did not get any benefits. It was a waste of time for me (Türkan, February 2020).

When Tuba was asked 'Which PD experience has had the least impact on your practice', she said:

> It was dull training courses relating to usage of smart board within the FATIH project because if you know how to turn on a computer then you can handle ah smart board. I do not think I learned something new which supported my practice. Instead, the MoNE should have organised PD relating to developing lab techniques or creativity in science or how to write a project. I do not think, the MoNE pays attention to what teachers need. They just list training courses on the internet, but they do not contribute to my practice.

Darling-Hammond et al. (2017) found seven widely shared features of effective PD. Such PD: 1. Is content focused 2. Incorporates active learning utilizing adult learning theory 3. Supports collaboration, typically in job-embedded contexts 4. Uses models and modelling of effective practice 5. Provides coaching and expert support 6. Offers opportunities for feedback and reflection 7. Is of sustained duration'. (p. 1)

Both Tuba and Tamer indicated that the training activities they had to attend neither supported their teaching practice nor provided feedback or reflection. Therefore, teachers in Turkey do not find it beneficial to attend training courses. They attended compulsory training, which in general did not relate to their subject area. Tezcan and Tülin said that:

> I attended a 'work safety' course. To be honest, I did not get a benefit. I just attended it because it was compulsory. The MoE or school principal let us know whether there is a compulsory in-service training or not. I prefer not to attend non-compulsory courses (Tezcan, February 2020).

> I attended a 'first aid' course. I found it useful but I wish it should had been done more professionally. I also attended a course related to special education. What I mean is that I learned how to approach students who need special help. I also attended a 1-day course about usage of tobacco products and alcohol (Tülin, February 2020).

Teachers in Turkey preferred to attend online PD. There are three main ways to take PD in Turkey. The MoNE provides in-service training. Some nongovernmental organisations also promote teachers' development. As in other countries, teachers also find PD by themselves (see Figure 5.33).

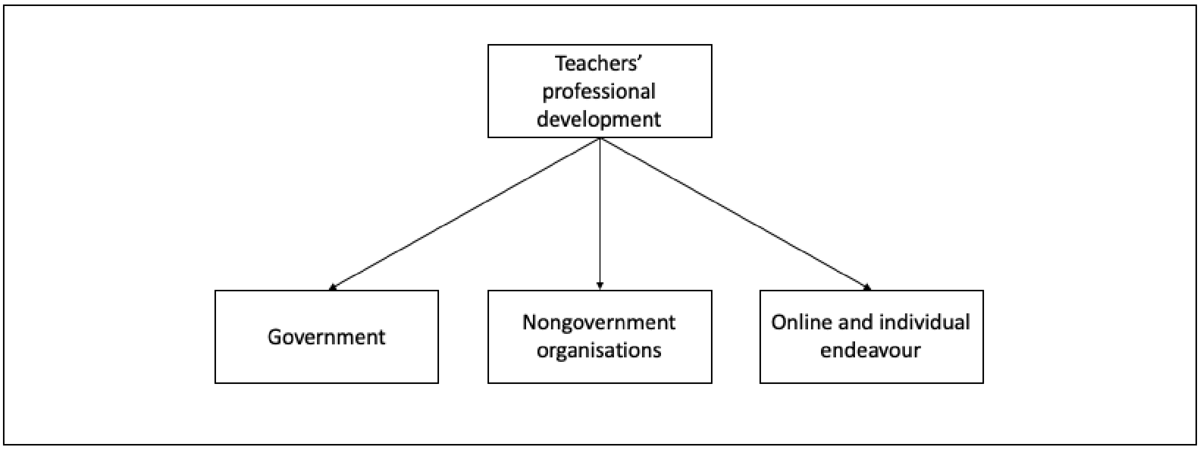


Figure 5. 33 Professional development pathways for teachers in Turkey

The findings also indicated that teachers in Turkey are not provided with effective PD. Instead, they attended mandatory and 1-day in-service training. PD in Turkey is not mandatory. Teachers do not need to complete a certain number of hours. This situation ends up in their losing motivation and not going to PD. For example, Tolga, Tülin, Temel, Tezcan, and Tamer do not attend any subject-specific PD. The teachers explained why they are demotivated. First, nearly all of the teachers think that the courses on offer are not effective. Although they attend training, the contents of the courses do not contribute to their practice. Second, courses are not designed around teachers' needs.

5.6 Conclusion

Chapter 5 presented deductive and indictive themes comes from four nations to investigate teachers' perspective on great teacher and how they are generated. Results showed that teachers in South Korea tend to participate in community-based generic programmes for developing their science teaching. Teachers in Israel and England tend to participate in school-based or topic-specific programmes provided by external organisations like the RSC and ASE. Teachers in Turkey tend to participate in compulsory and out-of-topic in-service training (see Table 5.1). Turkish teachers have fewer opportunities to develop knowledge and they undertake fewer collaborative activities than their counterparts in the other three countries. This situation contributes to reducing their motivation for teaching.

Table 5. 1 Professional development types and models

Countries	PD type	Model	Develop/enhance
England	Topic-specific	School-based, online (through social media)	SMK, subject pedagogy
Israel	Topic-specific	Cascade model, learning community close to home	SMK, intellectual virtues, knowledge of students
South Korea	Generic	Community-based	PK, CK, Knowledge of students, decision-making, judgement
Turkey	Out-of-topic and compulsory	Internet-based, centralised model	Networking

The teachers' view on PD showed that teachers in England tended to update their subject matter knowledge and teaching skills. Therefore, PD in England paid much more attention to cultivating SK rather than developing character virtues. In contrast, teachers in South Korea tended to attend generic PD because they believed that their subject matter knowledge was good enough to teach their subject. PD in Korea are designed to cultivate civic, performance, and intellectual virtues rather than to make their SK great. Israel provides its teachers with subject-based PD. As in England, science teachers are in short supply in Israel. Teachers without specialist expertise are employed as science teachers. Israel has built community-based PDs to develop their teachers' SK. In Turkey, PD is centralised, and it is not mandatory. The MoNE provides teachers with training courses at the beginning and end of term. Therefore, teachers in general are not satisfied with PD nor they do not think the PDs that are offered provide what they need.

Teachers in all four countries attend to character virtues, but do so in different ways. Teachers emphasise characteristics of great teachers, including the characteristics of a reflective practitioner, educator, lifelong learner, and moral exemplar. Teachers in England thought of great teacher as being a reflective practitioner. Critical reflection is acknowledged to be the most important element of effective teaching (Brookfield, 2017; Schön, 1983). Professional practice here refers to a teacher's ability to self-reflect and the "repertoire of effective teaching strategies and use them to implement well-designed teaching programs and lessons" (White, 2021, p. 170).

Teachers in Israel see great teacher as being an educator. Allen, Hafen, Gregory, Mikami, and Pianta (2015) highlighted that students' well-being in the classroom is as important as their cognitive success and becomes possible when the teacher creates a positive learning environment. Research shows that developing students' well-being has a positive impact on students' academic achievement (Howell, 2009; Suldo, Tuhalji, & Ferron, 2011). Teachers in Israel stated that being an educator comes before being a teacher. Therefore, being a reflective practitioner plays an important role in investigating what works in the classroom. However, having a reflective practice might not be enough to support students' emotion, well-being, and positive climate. Therefore, being an educator requires knowing how students feel and how they become happy in the classroom.

Teachers in South Korea believed that great teacher is being a lifelong learner. Educators should also maintain a lifelong learning mindset, that is, a driving force to update their knowledge and to reflect on it. In this study, South Korean teachers thought that great teaching incorporates passion, love, and affection.

Finally, Chaves (2021) indicated that being a moral model has a crucial part in the development of academic abilities, despite the traditional viewpoint held by many educators that learning is only a cognitive process. In line with this, teachers in Turkey thought of great teacher in terms of being a moral exemplar. They believed that teachers were not only responsible for delivering CK, but for also being a moral exemplar. The next chapter answers the RQ3.

Chapter 6: Supporting practical wisdom in practice: Subjectification and socialisation

"Every teacher needs to improve, not because they are not good enough, but because they can be even better".

-Dylan Wiliam, SSAT Conference in December 2012

6.1 Introduction

This chapter attempts to address RQ3 on how teachers develop their personal and professional qualities while being educationally wise. To answer this question, I employed the concept of practical wisdom as a prescriptive for understanding teachers' social learning in terms of fostering their PCK, PB&V, practical-moral knowledge, and passion as a novel approach in teaching practice. I paid attention to teachers' professional learning experiences and how these contribute to becoming a great teacher. By examining all data sets through a perspective of practical wisdom, I identified practical wisdom as represented by subjectification (dispositions relating to what makes great teacher and teaching i.e., PCK, PB&V, practical-moral knowledge, and passion) and socialisation (a perspective of how those qualities of great teacher and teaching can be fostered i.e. CoP and social learning approach). I drew on Wenger's (1998) CoP as framework, which is supported by Kind and Chan's (2019) PCK approach and a philosophical approach of Biesta (2015) to develop teachers' practice and understanding of great teacher. In addition, I found elements that seemed to promote or prevent the development of practical wisdom. Before I present the data, I revisit the notion of practical wisdom in educational contexts and explain why I chose this concept in Section 6.2. I next present instances of practical wisdom discovered by inductive coding, such as practical moral knowledge, passion, and a sense of professionalism, in Section 6.3. Finally, in section 6.4, I identify factors derived from interview data that support/inhibit the development of practical wisdom. Section 6.5 draws conclusions.

6.2 Developing practical wisdom in educational settings

This section reconfirms and expands on the notion of practical wisdom in educational contexts. The idea of practical wisdom is recognised as a vital component of teachers' professional development (PD), as previously addressed in Chapter 2, Section 2.5, meaning that a teacher's (re)construction of professional knowledge, beliefs and practices needs teacher practical wisdom (Stenberg & Maaranen, 2022). In recent years, this concept has been utilised to characterise and understand the components of teachers' activities in the context of CoP (Salloum, 2017). It has been used to evaluate teachers' decision-making processes and their level of support for PCK and practical knowledge (Shulman, 2007; van Driel et al., 2001). Thus, the degree to which teachers engage judgement and practical wisdom in their decision-making may make a significant impact on how (and if) the teacher implements practice in ways that directly support their students' engagement and learning (Salloum & Abd-El-Khalick, 2010, Salloum, 2013; Windschitl, Thompson, & Braaten, 2008) .

However, there is currently a lack of understanding of how practical wisdom influences science teachers practice in general and chemistry teachers in particular and how practical wisdom can be developed through a CoP. It is critical to identify key factors and those that support or prevent its implementation. This highlights the need of undertaking research on how practical wisdom might manifest itself in practice, how practical wisdom might evolve over time, which factors and instructional settings facilitate the development of practical wisdom. To address these points, my study captured how teachers' practical wisdom can be developed through the notion of CoP with a focus with critical, collaborative and reflective practice (Korthagen, Loughran, & Russel, 2006). As such, the objective of this comparative study to examine practical wisdom as a way of interpreting teachers' personal and PD. Moreover, determining the influence of teachers' personal backgrounds (e.g., beliefs and virtues) and dispositions on their practical wisdom is necessary to improve their wise-decision making and practice (Biesta, 2015, 2016). As such, variations of this phenomenon in practice need to take into account professional knowledge (CK, PK, PCK), personal qualities (belief, virtues) and professional qualities, which shape teachers' practical wisdom in their own classrooms. These might occur through CoP. The notion of CoP might foster the teachers' professional beliefs, values, knowledge, and skills in their teaching and the structure and culture of schooling that provides space for teachers to develop and shape their practical wisdom in practice. I therefore placed great emphasis on teachers' personal and professional qualities of teachers (as previously presented in chapter 5). As mentioned earlier, in my own study, I referred to Kind and Chan (2019), Kind (2019) and Wenger (1998) as well as a philosophical approach of Biesta (2015, 2016) to identify components of practical wisdom, which can be a potential to define great teaching and teachers, and how they develop. Kind (2019) offered three conditions which influence students' learning. Her findings showed that students' meaningful learning can be possible, when teachers' CK and PK are great. Students' learning still can be influence positively to some extent, when teachers have low quality PK and content is correct. In this scenario, students' might not learn something meaningful. The last scenario is lack of PK and CK. In this case, students' leaning tend to influence negatively which end up with irrelevant or misunderstanding on topics. Therefore, it is important to have good PCK, which has the potential to contribute significantly to students' learning. Later, Kind and Chan (2019) proposed a PCK model. This model separated PCK into two components (PK and CK) and added knowledge of students (KoS). This distinction leads to discuss practical wisdom that supports students' learning. However, neither Kind and Chan (2019) and Kind (2019) mentioned how great PCK could be developed. Therefore, this study benefits from the notion of CoP which might shape teachers' knowledge and support practical wisdom. Finally, Biesta (2015, 2016) suggested a perspective to define what great teacher looks like. He pointed out that teachers' knowledge and competence can bring about positive changes in education, so long as teachers have practical wisdom, which comprises PCK, PB&V, practical-moral knowledge, and passion.

This chapter focuses on how teachers in this study develop their practical wisdom. Semi-structured interviews with teachers, classroom and PD observations and focus group interviews showed that CoP was not sufficient to change teachers' PCK and beliefs on teaching science. The CoP provides teachers' with environment where they facilitate each other's PD. Practical wisdom added a new approach to support teachers' PCK and CoP. Previous literature on practical wisdom influenced my study's rationale and conceptualisation of this concept, particularly the work of Kind (2019), Wenger (1998) and Biesta (2015, 2016). Taking these scholars' conceptualisations of practical wisdom into account, I described practical wisdom as comprising five components: a CoP, a teacher's PCK, PB&V, practical-moral knowledge, and passion. To identify CoP, I looked for mutual engagement, shared repertoire and shared vision of teachers when they meet at community-based PD to determine whether those elements contributed to their teaching. For PCK, I looked for teachers' CK, PK and KoS to determine whether those components of PCK influence teachers' decision-making. For PB&V, I looked for intellectual and performance virtues of teachers to investigate how those personal qualities influence teachers' educationally wise judgements. I looked for pedagogical reasoning to determine practical-moral knowledge. Finally, I identified passion as an important dimension to become a great teacher.

6.3 Developing practical wisdom in teacher education

This section addresses RQ3, namely, how and why teachers develop their practical wisdom. Thus, this section introduces two themes that emerged from the inductive coding. Findings relating to how practical wisdom influences teachers' practice are presented in the two subsequent subsections. In this study, some nations contributed significantly to their teachers' practical wisdom. Some nations need to develop more effective CoP than others do. As shown by my observation of PD, interviews and classroom observations, South Korea, provided teachers with more opportunities in professional learning where teacher influence and learn from each other through mutual engagement, shared repertoire, shared vision, reflective practice, intellectual virtues. This is true to some extent for Israel and England but it is not applicable in Turkey.

6.3.1 Subjectification: Phronesis (practical wisdom)

Biesta (2009a) argued that there are three dispositions which influence teachers' PD. He offered subjectification as a new approach to identify what makes great teaching. The notion of subjectification is explained by Biesta as a means of developing teachers' practical wisdom through educationally wise-judgement ability. Teachers in all four countries attend to practical wisdom. It is founded that practical wisdom contains PCK, PB&V, practical-moral knowledge, and passion. These are all essential features for delivering knowledge to students and influencing students' meaningful learning. The findings show that teachers emphasise characteristics of great teachers, including the characteristics of a reflective practitioner, educator, lifelong learner, and moral exemplar. The reasons for the differences result from culture and the value placed on teaching. The value that is placed on teaching is likely to influence the beliefs and virtues teachers apply in terms of what kinds of teachers they want to be. The culture placed on education is likely to influence the approaches and perceptions teachers gain about what great teachers look like.

6.3.1.1 Practical-moral knowledge (P-MK)

The previous chapter presented the study's findings on three deductive themes, namely CoP, PCK and professional beliefs, and virtues, which emerged from the literature review and document analysis. This section deals with the themes of practical-moral knowledge and passion, which emerged from the inductive analysis of the semi-structured interviews, focus group interviews, classroom observations, and PD observations data sets.

In this study, teachers in England associated great teacher with being a reflective practitioner. In their interviews, they highlighted the importance of intellectual virtues to support practical wisdom. The reason why teachers in England focus on reflective practice relates to the Aristotelian conception of phronesis, i.e., practical wisdom. After Schön proposed the concept of reflective practice in 1983, a shift took place in education. Teachers are active learners, who reflect back their implicit and tacit knowledge to develop their classroom practice (Schön, 1983, 1987). This shift resulted in investigating how teachers became reflective practitioners in the classroom setting. The Reflective Practice Project (2001-2003) in England, coupled with the Autobiography Project and the Professional Identities Project, focused on investigating impacts on early-career teachers' growth and learning, with a focus on how they become reflective practitioners. (Moore, 2004). Reflective practice enhances teachers' teaching strategies and resources and teachers' professional knowledge (Tummons, 2010). Elizabeth's teaching is driven by her beliefs and values. In her initial interview, this is how she described her beliefs about teaching chemistry:

> I think that it needs to be right for the topic that you are particularly doing. So, some topics really lend themselves to experimental works. And then you should do experimental works. You should look at the children in the classroom that you have got, and you should decide what is right for each student overall. So, I have not got a specific fixed approach to teaching. It all depends on what I would like to do. Applying right instruction is allowing the students to be the centre of that and ensuring that the student works rather than you doing the work. It depends on the year group. For example, in my sixth-year group are

> working on peer assessment at the moment and understanding how to give feedback, what it is the significance of feedback, how to be specific in that feedback and the reason is I am trying to get them to have a little bit of metacognition about their own work (Elizabeth, February 2021).

The quotation above indicates that Elizabeth uses reflexivity in her practice. She emphasised she did not have a 'one-size-fits-all' approach to teaching chemistry. Elizabeth's beliefs contribute to her moral virtues by highlighting critical decision-making and caring for each child in the classroom, and her pedagogical strategies to engage students in tasks. Her beliefs allow her to develop knowledge of assessment. The statement above shows that Elizabeth's PB&V influence her PCK through self-reflection. The notion of effective teaching is associated more with reflective practice that is likely to be a prerequisite for gaining Aristotelian practical wisdom and judgement rather than with being a skilful or competent craftsman (Cooke & Carr, 2014). Barnes highlights effective teaching comprises intuitive judgment, which is likely to be developed through reflection (Barnes, 1992). Issues arising in the classroom can be difficult to address because students have different backgrounds, skills, abilities, and competence. This diversity in the classroom may cause uncertainties about what kinds of instructional strategies the teacher should use to engage all students. Addressing this issue is difficult for teachers. The findings from semi-structured interviews indicated that coping with such issues and uncertainties in the classroom requires practical-moral knowledge (P-MK). In her interview, Emilee pointed out that it is important to know 'how did it work' rather than 'what works'.

> You know before I get into the classroom, I am thinking about 'thinking hats', 'brain gym', 'learning pyramids', and 'Seneca learning', as all the learning styles, so there is something in there which appealed to education in the UK, as all this worked but without thinking about how it worked. Now we have got more research published by universities in the UK and US (…) For example, one strategy to teach acid and bases works well but the same strategy may not work to teach bonding and I think while one strategy works well for Key Stage 4, you might need to use different instruction for Key Stage 5. So, there are lots of variables. I think teaching involves a sort of practical deliberation (Emilee, February 2021).

As the above quotation shows, teachers should possess wise decision-making and engage in deliberate actions. These are essential for the best presentation of the topics in the classroom. Loughran (2019) in this regard, associates teachers' practice with pedagogical reasoning, which is concerned with what teachers know, how they know it, and what works in their practice. In line with, Loughran's (2019) perspective Emilee showed that she reads articles relating to teaching and learning science to know about what works. She has a wide range of knowledge on instructional strategies to deliver knowledge to students. However, she added that critical analysing of her professional knowledge to choose the best ways to teach her subject was needed. In her interview, Elizabeth made a point of highlighting the importance of wise-moral judgement, as it influences what kinds of pedagogical strategies she would choose. Elizabeth said:

> If there is a topic which I do not really like teaching, I will be honest with you, for example, composite materials is not a favourite of mine. I would do that as a collaborative group exercise, where the pupils present that to me. That is an opportunity for them to be able to teach their peers about a particular topic. So independent learning is going on there. If I do not like particular topic like composite, I also use the direct instruction model and flipped learning. So, I have not got a specific, fixed approach to teaching (Elizabeth, February 2021).

The excerpt from Elizabeth showed that she reflects on when she uses didactic teaching or independent learning. She integrates contrasting perspectives to teach different topics. If she has to teach a topic which she does not like, she then decides the most suitable approach to engage students with the topic. This example shows that teachers' PCK is topic-specific and personal (Kind, 2019). P-MK is important quality which shapes teachers' PCK.

Teachers in Israel described great teacher as being an educator. In their interviews, they paid attention to moral and civic virtues, which contribute to students' well-being and human flourishing. When it comes to how Irit's PB&V influences her PCK, she explained:

> They need to feel that the teacher is not an instructor. A teacher is person that takes care about their students. When I teach, it takes about 1 to 2 months until students get to know me and understand that I really want to help. When they understand it, we are equal, like they are important for me and I am very important for them. Some of the students in my school behave badly outside of the school, but when they come to chemistry class, they change because they understood they are in different environment. So, the environment in the class needs to be a place where students are made to feel free to communicate with the teacher. Students ask the teacher to help even out of class. For example, I live in a place where 50 minutes far away from school. I suggest students can come to my house whenever they need support both with content that I teach and other issues such as psychological or parental issues (Irit, February 2020).

The above quotation indicates that Irit prepares a classroom based on mutual understanding. To be educator, Irit pointed out putting that students should be at the centre of learning. She said

> Nowadays, students, they do not like difficulties, so it is important make chemistry topics fun and interesting, make them relevant. Chemistry is important because it explains what happens around us, so the relevance is really important. Teachers should teach in different ways based on students' skills and needs. Chemistry is an abstract subject, so you need to get help from different sources and make topics easier to understand for students. Teachers should seek to find ways to get students engaged with the topics. Therefore, teachers in the classroom should know how to deal with students' actions and think critically about how to apply the best instruction like argumentation (Irit, February 2020).

The two excerpts from Irit indicated that phronesis, explained in section 2.6, is central to enacting the right course of intellectual action through critical thinking, wise decision-making, and reflection. Irit, for example, mentions changes in students' behaviour in and out of the classroom. She prepares a classroom where all are equal as human-beings, including the teacher herself. Creating this atmosphere is possible through mutual engagement. Irit is authentic in her instruction because she is approachable to her students and takes care of them in and out of the classroom as an educator. Although Israel is a multicultural nation where Arab and Jewish communities make up the biggest sector, Ivana, as a representative of Arab sectors, and other teachers believe that educating students comes first then teaching them science. Idit was asked, 'what makes a teacher great?'. She replied:

> I think good teachers are those who communicate with students, do not see students as students but as a human being. Try to see his student's strengths. Help using the strengths and try to help students to show their strengths. Because all of us, we have strengths and weaknesses. So, a teacher should be very human-oriented. Of course, know about chemistry and pedagogy because if you understand chemistry then you can make judgements about pollution or how methane or CFCs are dangerous to our environment. Knowing about chemistry prompts you to make rational decisions. But more importantly, teachers should understand and accept that there are different types of students and learning, that you try to teach in a different way. Not have them studying for exams. Use an approach that education is a process. You should believe that students can change based on your behaviour. Even teachers should be careful while using language like superlatives, or phrasing words in the class (Idit, February 2020).

The quotation shows that Idit shows moral action in the classroom along with intellectual action. She thinks that science plays an important role in making judgments about societal issues. She points out that a teacher should be an educator who knows her students well. She highlights that if teachers know their students well, they can help students to be successful. As Idit said, a teacher should be human-oriented, as this virtue allows teachers to build a mutual engagement. According to Wenger (1998), mutual engagement facilitates learning between learners. In Israel, Reichel and Arnon (2009) conducted a study which explored cultural difference about what constitutes a good teacher in both sectors. Their results showed that, while teachers in Arab sectors linked a good teacher to being one who indicates ethical and moral character in front of students, those teachers in Jewish sectors identified a good teacher as one who shows good interaction with students. Where the Jewish sector is Western-oriented and the Arabic sector is traditional oriented, the "two different societies [that] can be characterized as more individualistic and more collectivistic accordingly" (Markic, Eilks, Mamlok-Naaman, Hugerat, Kortam, Dkeidek, & Hofstein 2015, p. 137).

Teachers in South Korea think being a lifelong learner makes a teacher great. Teachers stated that intellectual, moral, and civic virtues are important to be a lifelong learner. The notion of a lifelong learner may date back to 551-479 BC when Confucius lived. The philosophy of Confucius influenced East Asian countries such as China, Japan, and the Korean Peninsula. Confucius was an intellectual and he believed that moral character held the potential to promote how to develop practical wisdom. So-Yeon considers students' well-being in the classroom. She said:

> I was just delivering knowledge and information to students recklessly, blindly. But I recognised that it does not make sense just giving knowledge to them. Therefore, there is an education channel in Korea called EBS (Education Broadcasting System). With the help of visual aids from EBS, not only do I provide students with knowledge, but also at the same time I provide them with a humanity class. Then I recognised that after they watch it, they started to be interested in chemistry suddenly. So, it is too optimistic to expect students to engage in class by just giving basic knowledge, which does not motivate them to study. Instead, there should be something, which makes them excited about studying and motivates them and then they can motivate themselves. Actually, what students want is to hear motivational words or a real successful life story. Then they can associate the story with themselves. So, intellectual education and personality education go hand in hand. Then it is possible to develop and cultivate knowledge and social awareness (IQ and EQ development). As a result, if I do not grasp the reality of school or vision of school or real circumstances of school and I just get my enthusiasm with me, it does not work. So, regardless of school, if I do not know students well, no matter how intelligent, skilful I am, I tend to fail. I think 'empathy skill' is really important (So-Yeon, October 2019).

The quotation from So-Yeon suggests that what students really need is to be considered as human beings. Providing only knowledge should not be the aim of education. Rather, students should be supported morally, socially, and emotionally. The 2016 publication of the Code of Professional Conduct for Teachers by the Teaching Council of Ireland, notes that teachers' professional judgement and practice are influenced by their engagement with and contemplation of various aspects such as students' progress, theoretical aspect, pedagogical content knowledge (curricular knowledge, SK, PK), ethical values and, educational procedures. (O'Flaherty & McCormack, 2019). When So-Yeon was asked if she would describe herself as a great teacher, she replied:

> I can describe myself as an active learner and eager to learn each moment rather than an 'great' teacher. I always try to stimulate something new. I read books and try to share important points with students. I constantly develop myself. I used to think that a good teacher is one who has knowledge ability but as time went by, I thought that a good teacher is one who keeps being passionate about having good conversation with his students (So-Yeon, October 2019).

The excerpt above shows that So-Yeon is a lifelong learner who develops herself continuously. Therefore, she describes herself as an active learner. This desire for self-development leads her to attend PD and to do activities. This motivation comes from passion for and enthusiasm about learning. The findings from analysis of classroom practices (see chapter 5) showed that teachers in South Korea are highly motivated to implement high-leverage practices (such as scaffolding support, instructional technology, and active student engagement) to support students' intellectual (curiosity, critical thinking), social (global citizenship, service), moral, and performance virtues (components of PB&V) by applying argumentation and flipped learning in the classroom and laboratory through identifying explicit pedagogical practices that impact positively on student achievement and learning (Windschitl, et al., 2008). Teachers in South Korea pay attention to gain students scientific literacy skills. Si-Eun, for example, explained why teachers should raise students with scientific literacy skills as follows:

> I studied about science, and I studied about nature, theory which are new experiences for me. So, I want to let my students know how beautiful and meaningful science is. There is a saying 'you can see as much as you know'. The more you know about science, the better you feel and see. Instead of living without knowing, it is better to know, to distinguish what is useful and what is harmful because the environment that we live in is surrounded with dangerous people. So, I need to judge if what they are saying is true or

> false. Not so many years ago, I think 5 or 10 years ago, we used to take medicine with water. We used the humidifier to kill bacteria we put the medicine into the machine and used it, but people did not know how harmful using humidifier with medicine was and they used it. Lots of children died in Korea, even 10 years ago. My husband likes taking medicine and he wanted to use that medicine in water but I denied it, so I did not let him use it. if you cannot distinguish, it causes a very dangerous situation (Si-Eun, October 2019).

This quotation from Si-Eun highlights that raising scientifically literate students is important for critiquing whether scientific knowledge is true or false. This ability might be made possible through virtue-based education that provides students with practical wisdom to cope with misinformation. To provide students with virtue traits like critical thinking, analytic thinking, and wise decision-making, teachers should themselves have practical-moral knowledge. Si-Eun was asked how her beliefs about teaching science contribute to making students reflective thinkers. She explained how the changes in the way she teaches have influenced her practice:

> In the beginning I was thinking that I had to teach everything in the textbook because I know everything related to topics and I just wanted to deliver what I have known already. But as time went by what I recognised was that if I do not make the topic ready for digestion and add my judgement on it and take it down to the students' level, then students tend to forget it easily. They cannot associate the abstract topic with anything, so in this situation I make the topic easier. Delivering the knowledge from somewhere to somewhere is not effective. What does matter is that when you take knowledge out, we need to reorganise that part and practice. If I am not clever enough to organise which knowledge is suitable for students, then it ends up with teaching like a lecture. I will teach an hour's class where students do not get anything. And probably students will forget it after 1 or 2 years. So, I just think where is value on education then? I teach something and students forget it or memorise it, sort of a vicious circle. Therefore, as time went by, I tried to cut out the time that I speak in the classroom. Instead, I let students speak and encourage them to speak more. So, my motto I could say is 'the less you speak, the better the class you create' (Si-Eun, October 2019).

This quotation indicates that teachers should add their judgement on the topic that they teach. However, this judgment could be used critically to provide students with just the right amount of knowledge, which then makes students discover the rest by themselves. Preparing a class where students actively and critically engage with the topic requires mutual trust and agreement between students and teacher. Teachers should create authentic outreach experiences for students' active engagement. Su-Mi's beliefs and virtues help her to decide what kind of a teacher she wants to be. When she was asked ‘What would you say are your professional beliefs about teaching chemistry?’, she said:

> It is an interpretation of current issues and phenomenon matter. So, I want my students to grow skills based on having logical basis of scientific issues and matter. It should not be assertation, but it requires explaining phenomenon based on data. In the past, knowledge was considered important, but now it is important how to interpret that knowledge based on data you have. It is important to provide all students with educationally appropriate knowledge and information. Otherwise, we will raise a generation who lacks knowledge. For me raising people who cannot interpret knowledge and just follow others’ opinions is the most dangerous thing (Su-Mi, October 2019).

The excerpt shows that Su-Mi pays attention to raising a scientifically literate generation. She thinks if she raises scientifically literate students, those students will gain judgement and practical wisdom which will help students to interpret societal issues critically. She notes that students’ intellectual development is essential. She stresses:

> I found really important to feed students’ intellectual improvement, to get them recognised it is not just a matter of learning chemistry, using chemistry as a ladder to reach society. I think those sorts of activities like being interested in art or literature for science teacher are important to make connection between society and class and society and students’ minds. So, I like going to club activities based on social science (Su-Mi, October 2019).

The quotation above shows that Su-Mi sees students’ intellectual development as important in addition to their becoming knowledge people. The reason why teachers in South Korea tend to pay attention to students’ emotional, social, and intellectual development might be related to South Korea’s competitive education system. Teachers like Seon-Mi, Sang-Cheol, So-Yeon, Sung-Sook, and Su-Mi are more interested in preparing an environment where students feel stress-free and enjoy learning science. Those teachers focus on developing students’ character virtues rather than academic achievement, because as Seon-Mi mentioned earlier, private academies provide students with knowledge. In line with the semi-structured interviews, focus group interviews supported the significance of wisdom which provides teachers with better insight into their educationally appropriate judgement ability. In the focus group interviews, when teachers discussed a statement in task 2 about self-reflection, Sung-Hwa from focus group 2 raised awareness about the importance of self-reflection. She said:

> If you do not know about your strength and weakness about your teaching, you cannot improve yourself. That is why reflection on your teaching comes first. If you are reflective on your teaching, then you can have proper beliefs and personal values about teaching (Sung-Hwa, October 2019, Focus group 2)

In focus group 1, Su-Gil provided the same perspective. She indicated that:

> If you want to improve the ways you teach your subject, it is essential to be reflective. Being reflective gives you detailed information on how to handle any weakness or shortcoming that you possess. It is therefore important to attend PD where you can get feedback and ideas from your colleagues (Su-Gil, September 2019, Focus group 1).

Sung-Hwa and Su-Gil indicated that the most important component of wisdom is reflection. Being reflective promotes wisdom. Sung-Hwa thinks the most important skill that teachers should have is self-reflection. This leads teachers to think carefully about their shortcomings and how to overcome them. Section 5.4.1 discussed the idea that communities are the best places for PD because joint enterprise with other teachers provide teachers with the opportunity to reflect on themselves.

Finally, teachers in Turkey considered great teacher as a being a moral exemplar. They highlighted the importance of having students gain moral character which supports practical wisdom and has the potential to lead people to live good lives. The Jubilee Centre for Character and Virtues (2017) focused what meant to be a great teacher. In order to excel as a great teacher, it is imperative to possess or cultivate a specific set of qualities. These include upholding strong moral principles and demonstrating unwavering dedication to the subject matter being taught. The fundamental aspects of a teacher's effectiveness in the classroom are their character and integrity, which hold equal importance to their mastery of subject content and instructional techniques. (The Jubilee Centre for Character and Virtues, 2017). Although Turkish teachers highlight the notion of the teacher as a moral exemplar, classroom observations of Turkish teachers indicate that they did not have the opportunity to show moral action in the classroom.

6.3.1.2 Passion

This section presents the findings relating to teachers' passion and how it plays an important role in effective teaching. As Day (2004) argued dedicated teachers acknowledge the difficulty of the wider societal circumstances in which they teach, possess a distinct sense of self, and maintain the belief that they can positively impact the learning and accomplishments of each of their students. (Day, 2004). In his interview, Ethan said:

> I am willing to look at new ideas and new ways to do labs because science is changing all the time and courses are changing. I think a great teacher should be able to care for and give formative reports to the pupils. Recognizing the visible science with which students struggle and ensuring your ability to support and help them—I believe that great teaching requires dedication, hard work, and enjoyment of students' company (Ethan, February 2021).

The excerpt shows that Ethan puts passion as a quality of a great teacher in second place after SK (see Section 5.2.2). When Irene was asked in her interview about the qualities of a great teacher, she said:

> Being passionate about teaching, always trying to innovate, seeking for new ways to explain difficult stuff, using many ways of teaching (movies, animation, models, cellular in class, teamwork, and more), see what interests youth and connect it to life and be relevant (Irene, April 2020).

Passion is a power that encourages teachers to learn more about the subjects they teach. Irene for example indicated that she has a passion for scaffolded different instructions, which supports her students to develop skills and new concepts. Previous studies showed that passion is linked to students' performance (Vallerand, Salvy, Mageau, Elliot, Denis, Grouzet, & Blanchard, 2007). Ilana is a dedicated chemistry teacher who encourages their students to do volunteer work for society.

> I want to contribute to the community that I live in. As a chemistry teacher, I encourage my students to do some projects for society and I am a role model. I start doing and show them how to do that. For example, we have a chemistry laboratory at school; we are making hand cream and go to care homes where people need extra support. We apply hand cream to their hands. I also invited elementary school students and their teachers to share our laboratory. I also organise science fairs for women (Ilana, January 2020).

The excerpt from Ilana indicated that possessing passion is linked to civic virtues and supporting society. In Turkey, Türkan does not attend any PD other than those that are mandatory. On the other hand, she is quite passionate about teaching biology. She explained:

> I haven't attended development courses, although there have been lots of them. I think I have a different personality and characteristics. I am already improving myself. Lots of my colleagues have attended those

courses like usage of laboratory equipment, effective usage of laboratory etc. I developed myself when I was at university and I became someone that can give courses to other teachers. I taught courses for other teachers one year. Moreover, nine pilot schools, which were the top schools in Turkey, had been selected and I went to those schools to explain how to use the laboratory effectively and how to carry out experiments. Therefore, I did not need to attend courses. For example, the MoNE provided teachers with a compulsory computer course 'the usage of interactive smart board' but I already know how to use a computer and how to integrate it with smart board, as I wrote a handbook of biology experiments. While writing the book, I learned everything about computers. I built a laboratory after I had been appointed to my first school in Agri, which is located the north-eastern corner of Turkey, in 1990. In 1992, I also built the laboratory at my new school in Konya. In 1995, I built the laboratory in a religious high school. I build the laboratory three or four times in penultimate school (Türkan, February 2020).

The excerpt above shows that Türkan has got intrinsic motivation to learn, which results in doing different things by herself. As she is an active teacher, I asked her a follow-up question: 'Have you ever thought of establishing a community among biology teachers to exchange knowledge expertise here?' She answered:

We are a biology teacher of six in this school. I also used to be a chairman of biology teachers in Konya. As you know, the system is a bit complicated in Turkey. You discuss what should be done or changed in relation to curriculum, instruction strategies etc. but nobody cares about your opinion. They just do what they want to do. Although, I have let them know about what should be done, they haven't listened to me. It always happens. So now I'm fed up with doing something. I just gave up. There are six biology teachers. I let them know before I set up the laboratory. Nobody was interested in me. After I had designed the laboratory, I wanted to give them the key but they refused it. They said they did not use the laboratory; they did not do experiments. When I heard that, I lost my motivation to do something (Türkan, February 2020).

The quotation from Türkan indicates that teachers in Turkey feel alone and unsupported by either the MoNE or their head of school. No communities provide teachers with an environment where teachers meet with each other in mutual understanding. In South Korea, nearly all Korean teachers mentioned passion as an important indicator to be a great chemistry teacher. In her interview, Si-Eun said:

I really want to teach science to someone who really does not know about it. I want to make them aware how wonderful science is. If they know about science, their life can become more affluent. I like learning and teaching. I have passion about learning and teaching. Nowadays, I am working on my paper, which is

> about 'good science teaching'. I would say just one word [about] how to be a good science teacher. It is 'love', love [your] subject, love students and love nature (Si-Eun, October 2019).

When I asked Seo-Jun about what qualities make teacher great, he said:

> Possessing affection for the subject you teach and having a sincere heart are key to being a great teacher, followed by a good relationship with students and caring for them (Seo-Jun, October 2019).

If a teacher is passionate about teaching, he/she tends to spend more time on performing a variety of activities to share their expertise. Similarly, Sung-Sook for example visited Tanzania, East Timor, and Gure (a suburban area in South Korea). She explained her motivation for going to those places:

> What makes me motivated to go to Tanzania is the spirit of sharing and being useful for others. I helped design a laboratory for Tanzanian students, who are willing to learn science. I enjoyed doing experiments there with my Tanzanian colleagues. I shared my experience with them. Gure, for example, is a city. Laboratories in schools there are not well-equipped. I went down there and helped my colleagues there. What I think is that doing those sorts of activities makes education meaningful (Sung-Sook, October 2019).

The excerpt from Sung-Sook indicated that possessing passion is linked to civic virtues and supporting society. Sung-Sook thinks that sharing experience with others and helping others makes teaching more meaningful. Education is an active way to foster others' learning processes and contributes to their learning in a meaningful way. Sung-Sook expanded on what she meant:

> For the last 6 years, I have been working at the same high school. During those 6 years, I have been running chemistry club, where lots of activities are going on there. For example, I take my students to a children's community centre, this is, where students who are from disadvantaged backgrounds come together. My students prepare experiments which they have performed before. Then they take these to the children's community centre to carry out basic science experiments for elementary students. It is a way of linking to society through science. I want science to be a bridge between people. Meaningful science. science for better society (Sung-Sook, October 2019).

Thus, passion incorporates supporting students' learning and developing new concepts and skills, which in turn support human flourishing. As seen in the above quotations, passionate teachers promote their students' passion, thus supporting students' civic and performance virtues (see Section 2.5.3 and 2.5.4). When discussing "Statement 2" in the focus groups, Su-

Nam highlighted the idea that attending PD and sharing what you had done there helped you to gain credit in students' eyes.

> Whatever I do for example attending PD and doing self-improvement, I just try to provide my students better environment. To be honest, I go the extra mile for learning something different and I spend time for it although I feel sometimes overwhelmed. I am really passionate on teaching and learning new strategies. As I attend this activity (Shingwaram), my teaching life is changed. First, I actively get what other teachers presented here. It helps my improvement a lot. I feel I Improved. As my students see my improvement, they also give positive feedback to me (Su-Nam, October 2019, Focus group 2).

In focus group 3, one of the chairpersons of Shingwaram said that

> Shingwaram is actually the abbreviation for 'Teachers who love teaching science'. It means teachers who come here have passion for what they are doing. We as teachers who love science build this course, so we have a synergy between teachers. We have a community sprit here. That is why every teacher who comes here has a goal to achieve or knowledge to share with us. Not government appointed somebody to give a lecture to us, we decide what we need and choose what we will do to improve students' understanding of science (Sang-Cheol, October 2019, Focus group 3).

The two quotations from the focus group interviews indicated that passion is a starting point for effective teaching because it triggers teachers' beliefs and makes them motivated to learn something new and to add that to their repertoire. Findings from PD activities showed how passion plays an important role in motivating teachers to develop themselves. At a PD session held on 15 October 2019, So-Hanji shared her experience about a South Korea-Tanzania science collaboration workshop. Her presentation contained three parts. In the first part, she explained the workshop. In the second part, she explained the changes that she had gained through activities, and in the final part, she provided a general overview on this field trip. This PD session was important to make teachers motivated.

6.3.2 Socialisation: Sense of professionalism

Biesta (2009, 2015) pointed out socialisation which supports sense of professionalism is an important domains of PD. Regardless of their nation, teachers have certain beliefs and virtues which tend to shape their PCK and practice. Nespor (1987) supported the results of the study. The notion that the ways of thinking and comprehension of teachers are essential elements of their work has gained widespread acceptance.(Nespor, 1987). A key factor that helps develop practical wisdom identified in this research is CoP. Nations which build strong communities of practice attempt to support their teachers' practice and beliefs in a positive way. Nations that pay little attention to establishing strong communities of practice tend to provide limited support for their teachers. Research indicates that PCK-based teaching practice influences students' academic achievement positively when teachers come together collaboratively (Bausmith & Barry, 2011; Gore et al, 2017; Vescio et al., 2008). Similarly, Fullan (2007) indicated that given that one's actions are influenced by their interactions with others, relationships with other teachers represent a crucial factor to consider. The development of novel meanings, behaviours, competencies, and convictions is dependent upon teachers working on their own or engaging in the exchange of ideas, assistance, and constructive views regarding their profession (Fullan, 2007). When teachers come together, they are likely to add new ideas and concepts to advance their repertoire in relation to practice. In her interview, So-Yeon indicated that

> In terms of developing tools to make students access information easily, I got lot of benefit from a research study group, because in that group, we are doing brainstorming about finding the best and easiest ways in which deliver knowledge to students. I put my idea on the table and other member of group also say their opinions and we find a solution (So-Yeon, October 2019).

In line with this, Ilana from Israel gave an example in chemistry about how groups of teachers tried to handle students' misconceptions on chemical bonding. She pointed out her interview

> There are lots of teachers. They can come with knowledge. They come with something that they are good at. Maybe they are good at creativity, technology, and all kinds of expertise. It depends on your weaknesses and strengths... For example, the structure of H_2O_2 is non-planar. However, students think H and O atoms were combined randomly. H is connected to H, and O is connected to O. But it is not like that. So, we can see it in the exam sheets. There are different versions of bonding that students draw in the exam. We share those drawings with each other to let each other know what motivates students to draw different structures. Based on the discussion that we had, I prepared different animations and different materials, as well as some videos, to explain chemical bonds. These discussions and sharing help me to be more creative and imaginative about teaching chemistry, which I would not be able to do on my own (Ilana, January 2020).

These excerpts from teachers in two nations demonstrate that collaboration produces something unique that promotes and facilitates student learning. These possibilities for social learning in community-based PD increases teachers' creativity and imagination. Teachers who participate in community-based PD have more opportunities to learn new teaching techniques and update their knowledge. As a result, they are critical of what and why they are teaching. Ilana, for example, pointed out socialisation when wanting to build a community where everyone shares and reflects their practice. Ilana highlights mutual understanding and trust among teachers. She explained:

> This is a PD, which is not school-based, that is outside of school. It is better. It is better to have it done outside. First of all, there is a problem if you do it inside of school which is lots of teachers in Israel are alone in school so they cannot work collaboratively with others like chemistry or content of chemistry. So, there is really a need for a community. Teachers in the school-based PD, they do not intend to say their true feeling. It is not easy to build a good community unless teachers feel trustworthiness. In here, what we are trying to do is to build a community based on trust. In school, the headteacher has power like I am head teacher, and you are teachers sort of, but in communities there is no power on teachers. It is good (Ilana, January 2020).

This quotation from Ilana shows that knowledge can be transferred so long as mutual engagement is built among teachers. Idit highlighted some points about how the leader teacher programme contributed to her virtue practice and knowledge domain of teaching when she said:

> I do not just go to school for doing something but for making learning easier and an enjoyable activity for students and to get them engaged in society. Therefore, in the teacher leader programme, I am with a group of selected teachers to develop tools, to learn more about misconceptions, and to try to understand difficulties as well as to try to think how to make change. So, we plan different lessons, so we had to work together. We learned a lot from each other. And we meet. When you meet good teachers, you can improve yourself. Also, a lot of activities that we had were implemented in the school and we have to report about it. It was not only studying and coming together in vain, but it was also about seeing what works or what does not work (Idit, January 2020).

Su-Mi in South Korea said that coming together with teachers who shared the same interest help her improve gaining judgement ability. She explained what she is doing for her development in the following quotation:

> I have an effort to develop myself by reading books relating to my subject and other kinds of PD books. I am also coming together once every 2 weeks with other teachers who share the same interests as me. We have a study group, which consists of four teachers. I have been doing this study group activity for years. I

> would also count master's and PhD as PD activities because I really learned a lot while doing them. I also had another meeting which was about "developing science experiments for middle school students." Nowadays, there is a programme supported by the education office. It is "science creativity camp" I come together with other science teachers like biology, physics and earth science teachers. Then we take students who are interested in science and then do research together and present it in science fairs (Su-Mi, October 2019).

When asked how PD impacts on her practice, Su-Mi said:

> To some extent, all the courses that I have attended have been useful for me. But, I would say that through the study group activity, I have gained different perspectives from my colleagues who have different experience and points of view. While doing my master's, I read different articles and dissertations; those also helped me out with constructing my knowledge. While doing my PhD, I learned different pedagogical theory. I also observed those theories while teaching chemistry in the classroom. It helps me gaining judgement ability. Having learned theory, I try to find which one is the most suitable for my teaching (Su-Mi, October 2019).

The excerpts above indicate that Su-Mi has dedicated her time to her PD. Her PD activities help to contribute to developing her judgement ability and gaining different perspectives which support her practical wisdom through collaboration. In terms of gaining benefit from Shingwaram, Sang-Cheol highlights the importance of collaboration, interaction, and sharing between teachers. However, he pointed out how PD contributed to society. He explained:

> Shingwaram got started with a volunteer science teacher activity, so another mission of this teacher meeting is to give us an opportunity to meet students who are economically disadvantaged children at a community centre. So, we go there and do some scientific activities, which aim at getting students to love science. Not only do I gain experience and update my knowledge in subject area, but I also do service for the society through Shingwaram (Sang-Cheol, October 2019).

The excerpt shows that Shingwaram encourages teachers to go the extra mile for students who are from disadvantaged backgrounds. Shingwaram contributes to teachers' knowledge about their subject, and helps to cultivate their civic and performance virtues. This PD connects teachers and society. Some teachers in South Korea, for example create a CoP in the classroom to motivate students to learn chemistry. Seon-Mi shows that applying to the elements of CoP in the classroom makes students motivated. She said she was always motivated to deliver the best class possible for her students. She said:

> I apply flipped learning in my class, as I believe that students have mutual relation while they provide rapports to each other. I almost do not deliver a lecture. If you a plan to start flipped classroom; students they are not familiar with that style of learning because it has been 10 years since they have listened to a lecture from a teacher from elementary to high school. If we do not have rapport with each other, it is very difficult to keep doing flipped learning. First, I build a relationship based on trusting each other. So, I try to persuade them why I need to apply this instructional strategy in the class. I prepare my students psychologically first. If they are not ready for collaborative learning, I cannot start to teach. But when I recognise their sparkling eyes and build sort of trust, then I became more motivated and try to handle things that I could not do in the past. I think the secret is connection between me and students based on mutual trust. Definitely, as students have in the classroom, I become motivated so what I do is to bridge between me and students based on trust and belief (Seon-Mi, October 2019).

Seon-Mi is quite motivated by what she is doing. This motivation comes from the passion she showed in her classroom teaching (see Section 5.4.2). In South Korea, the university entrance examination is competitive; therefore, students study hard to get into the best universities. For this reason, students go to cram schools or private academies after class. Seon-Mi explains how she makes her students motivated:

> I want them to write a piece of work about something. It does not matter whether it is scientific or not. I know that writing is a very important skill for them. I also introduce film, music, art, beautiful scenery. Last year, I watched 'A Star is Born' with Lady Gaga, Bradley Cooper. I really loved it. So, I introduced that film to my students and at break time I play music etc. My point is what makes our life comfortable is scientific technique but what makes our life rich and fruitful is art. So, listening to music, drawing a picture, watching beautiful scenery are ways to make yourself happy. I introduce those sorts of things to students so I feel rewarded and worthy. In terms of getting students to gain chemistry knowledge, I think instructors in cram schools/private academies are better than me, as they just focus on preparing students for 수능 (College Scholastic Ability Test). I am not that kind of person. I am a person that I want students to feel pleasure of life and have a good attitude to each other. Whenever I go on holiday, I take pictures and videos there. When I go to class, I show those places to my students. I love hydrangeas the most among flowers. So, when I go to Pusan and Jeju Island, I take pictures and show my students. So, I advise my students to live based on what they want. To reach your goal what do you need? What kind of job makes you happy or what kind of job takes you to reach your goal? I talk to students about lifestyle. I try to give as many examples from my live as I can. It is really very good when they remember one of the things that I have said (Seon-Mi, October 2019).

The quotation above indicates that Seon-Mi creates a classroom where students feel comfortable. She does not bombard her students with knowledge. Instead, she gives scientific knowledge which helps students to live a better life. She highlighted in section 5.4.3 that she wants students to be scientifically literate so that they can judge information around them properly. Sung-Sook exchanges her expertise with other teachers in PD and that doing so helps develop her knowledge and professionalism and the professionalism of others. She places Shingwaram in a central position because she is one of the chairpersons of Shingwaram. She explained how she benefits from Shingwaram:

> I will inform you about what we are doing in this teacher meeting. We have two sessions each meeting. Each Thursday, a colleague of mine presents his work to us and introduces new materials. Generally, what teachers present is about what they have already applied in their classroom and it works well. Then, we discuss about the topic which is delivered. As we discuss about the matter, we learn from each other. Generally, teachers who attend this meeting do not have fixed mindsets. I would say through interaction to each other and discussion we become 'growth-mindset'. Teachers who attend here are really good at their subjects and they have a variety of experience in teaching. As we share the knowledge that we have with each other, then we have got in-dept experiences. So, I would say Shingwaram helps improving teachers' expertise. Sharing materials, discussion, presentation, letting to know each other beneficial sites, those are the ways we exchange knowledge between us. After the presentation, I take the idea and apply it to my classroom. Later on, I can give feedback about whether it worked or not (Sung-Sook, October 2019).

Shingwaram supports teachers' professionalism, knowledge, and character development. As emerged from the document analysis, professionalism consists of collaboration, interaction, and continuous development. Shingwaram is a long-lasting PD which enables teachers to practice and reflect on their teaching. As Sung-Sook points out, teachers come together to build a growth mind-set, which leads them to practice in a minds-on in addition to a hands-on way. She wants to help other teachers and to do meaningful things for society and other teachers.

6.4 Factors that impede the practical wisdom of teachers

There are factors that hinder the development of practical wisdom. First, classroom observations in Turkey indicated that teachers follow the curriculum. The science curriculum for grades 9-12 (students aged 15-18) does not allow teachers to judge why the content would be taught. Teachers do not implement any extracurricular topics in relation to moral education nor do they try to explain things outside of the curriculum. Tamer highlighted how the examination system puts teachers off presenting virtues in their teaching.

> Currently, middle school students are preparing for entrance to a good high school, and high school students are preparing for entrance to a prominent university; thus, teachers must concentrate completely on problem-solving in class rather than ensuring that students fully comprehend their courses in high schools. Therefore, teachers cannot suggest, "Let's avoid problem solving and do an experiment instead." For instance, you may simply inform students about the definitions of acid and base and then have them immediately begin answering exam-related tasks (Tamer, March 2020).

Focusing solely on students’ exam achievement enables teachers not to attend to virtues in teaching. This ends up raising students focused on academic achievement. A lack of support from government in Turkey is a factor that demotivates teachers and contributes to teachers' losing motivation to update themselves. Tezcan who is a chemistry teacher with 6 years’ experience said:

> I attended in-service training related ‘how to use smart and interactive board’. I also attended a ‘work safety’ course. When I was in Bitlis, I used to attend a community meeting. Meeting content is sent by the MoNE. After that, teachers come together and discuss how to increase students’ achievement, what topics should be added or taken out to/from curriculum. I would not say I got benefit from those courses. We always raised our voice about what should be done but we did not see anything in return. For example, we let them know about our laboratory. The laboratory needed to be equipped but during the time when I was working there we could not get a response and we did not design our laboratory, such a shame (Tezcan, February 2020).

Özden (2007) pointed out that insufficient laboratory equipment for performing practical work, and deficits in science teacher education. He listed a lack of understanding of the nature of science among Turkish science teachers. Turkish science teachers’ epistemological beliefs about learning is still traditional and ‘top down’ approach in common in PD.

6.5 Conclusion

This chapter explores the ways in which instructors enhance their practical expertise and refine their teaching practice by active participation in a well-established Community of Practice (CoP). This study examines the personal and professional qualities of science teachers by employing the concept of practical wisdom as a novel framework for understanding the characteristics of exceptional educators and strategies for cultivating these qualities. The investigation is guided by the social theory of learning, incorporating the insights of Kind and Chan (2019), Wenger (1998), and Biesta (2015). During the course of conducting interviews and observing teaching practices, I discerned components indicative of practical knowledge. An analysis was conducted of factors that facilitated and impeded the development of practical knowledge in the context of scientific education. The subsequent chapter presents a summary of the findings from this investigation in relation to the research questions posed. It examines the study's significance in terms of educational knowledge and science education, while offering recommendations for future research and exploring the implications for various domains such as professional development, practical wisdom, and effective teaching practices.

Chapter 7: Discussion and Conclusion

"Education deserves emphatically to be termed cultivation of mind which teaches young people how to begin to think".

-Mary Wollstonecraft, 1792, p. 182

7.1 Introduction

Although personal and professional qualities of teachers are considered essential pillars of defining what makes 'great teacher' and teaching, explaining how those qualities can be learned and why teachers need them remains vague. It remains a challenge for both teachers and researchers (Coe, Rauch, Kime & Singleton, 2020; Kind and Chan, 2019) leading a number of researchers (Biesta 2015; Kind, 2009, 2014; Kind & Chan, 2019;) to emphasise the need for further investigations on how to support teachers' PCK, PB&V, P-MK and passion in science and chemistry education. Wenger's (1998) account of CoP is reconciled to professional development (PD) through mutual engagement, shared repertoire and joint enterprise, enable teachers to develop their practice. The current study has therefore examined how teachers developed their qualities in the process of planning, implementing, reflecting on practice, and evolving it in their practice through CoP approach. With this final chapter, I will be discussing the results of the RQs, focusing on whether the teachers participating in this study developed their personal and professional qualities through the concept of practical wisdom as a perspective.

This final chapter is organised as follows. Firstly, in section 7.1, I discuss the findings of teachers' perceptions of great teachers and their development in four case study nations including England, Israel, South Korea and Turkey. Secondly, in section 7.2, I draw together the findings of this study considering the RQs about why practical wisdom is necessary for teachers. In section 7.3, I discuss the contribution of this study to educational knowledge to science education, followed by suggestions for future research and implications for the different fields (e.g., professional teacher learning, practical wisdom, CoP). Section 7.4 addresses the limitations of the study, while section 7.5 makes recommendations for future study. Section 7.6 explains how this study has contributed to my personal development as a researcher, and section 7.7 summaries the thesis.

7.2 Perceptions of great teachers and their development

This section draws on previous research to discuss perceptions of great teachers and how they develop. The findings are based on interviews (focus and individual), classroom observations, and PD observations (as examined in chapter 5 section 5.1, 5.2, 5.3 and 5.4 for each nations). Moreover, I have used the concept of practical wisdom as a concept for my investigation of science teachers' teaching practice as a new scientific practice. The participant teachers in each nations were asked to investigate how PD contribute to their teaching practice and bring about changes their beliefs and virtues in teaching and what makes great teacher and teaching. This small-scale comparative case study's three research questions address an overall image of the great teacher and teaching in four nations and how practical wisdom scaffolds teachers' practice and understanding about teacher excellency. More specifically, this section of the study sought to gain insight into the following:

RQ1: In what ways are the educational systems of four nations (England, Israel, South Korea and Turkey) providing teacher PD that contributes to their teachers' practices?
RQ2: In what ways is the notion a 'great teacher' perceived in science teacher education in these four nations?
RQ3: How and why (if at all) do teachers gain wise education judgment/practical wisdom?

To address RQ1, I attended community-based PD, conducted interviews, performed document analysis and did focus group interviews. I addressed RQ2 by comparing for nations' perspectives through interviews, classroom observations, focus group interviews and document analysis. Finally, RQ3 is addressed by analysing interviews, classroom observations, focus group interviews, PD observation and document analysis. The next section discusses RQ1 for four nations.

7.2.1 In what ways are the educational systems of four nations (England, Israel, South Korea and Turkey) providing teacher PD that contributes to their teachers' practices?

A challenge is how to develop great teachers and their practice. Some countries increase standardisation of science teaching through establishing effective PD (Cochran-Smith et al., 2017), as building a high-quality PD has positive impacts on students' outcomes (Darling-Hammond et al., 2017). For example, South Korea and Israel emphasise collaboration between teachers and have developed community-based PD to help teachers exercise practical wisdom. Attending these communities and working collaboratively with other colleagues gives science teachers insights that scaffold self-reflection and in turn bring about changes in classroom practice. The next section discuss how CoP attributes to teachers' PCK development.

7.2.1.1 CoP contributed significantly to teachers' PCK development

Results from the document analysis showed that South Korea and Israel pay attention to developing teachers' PCK. In contrast, England and Turkey focus mainly on CK. Results from this study indicated that well-designed, long-lasting CoP contribute to teachers' PCK. In this study there are some exceptions. England is considered a high-achieving nation and Israel is ambitious to be a high-achieving nation based on PISA and TIMSS results. England focused on developing teachers' CK. While Israel focused on teachers' PCK. Community-based PD enabled Eliot, Ilana, So-Yeon, and Turgut to learn different instructional strategies, develop curriculum materials, update their curriculum knowledge, and reflect on their practice, according to their interviews. In Turkey, teachers received training courses, but those courses cannot count as a CoP because these did not provide teachers with an environment where they could reflect on their practice and engage with each other mutually. They simply became passive listeners, as Tamer pointed out in Chapter 5. In contrast, in South Korea, teachers who attended Shingwaram and other community-based PD were active participants who engaged with each other and shared curriculum materials.

7.2.1.2 CoP as a means of developing teachers' believes and virtues on teaching

Researchers are increasingly interested in examining the relationship between teacher beliefs and practice (Pajares, 1992). For example, in Israel, leader teachers (Ilana, Ivanka) in community-based PD shared their experience with novice teachers and gave them opportunities to develop their confidence. Poor conceptualizations and misconceptions of teachers' beliefs prompted researchers to examine teachers' beliefs (Nespor, 1987). The study findings showed that all teachers have beliefs about how and why to teach science. Positive or negative differences exist amongst teachers based on the topics they teach, and the curricula they implement. These result from whether teachers participate in an effective community-based PD or not. For example, from Si-Nan’s PD, he pointed out some societal issues pollution, global warming. So-Yeon in her interview in South Korea said to learn how to adopt Arduino software into chemistry teaching through study group. However, in Turkey PD is not designed to develop teachers’ pedagogy. For example, Tezcan and Tülin pointed out that they participated in compulsory teacher training based on first aid and work safety which are not related to chemistry teaching. This shows that if teachers receive PD opportunities, they might gain fresh insights into teaching chemistry. There is a trend towards implementing bottom-up, experience-based teacher training courses at both the pre-service and in-service levels, particularly in high-leverage nations like South Korea. Israel and South Korea have context-based chemistry education to guarantee sustainability. It is necessary to explore their tendency to make chemistry teaching relevant to establish well-structured PD for chemistry teachers in particular.

This study found that intellectual virtues can develop through a CoP approach. As explained in Chapter 2, there are different intellectual virtues. However, among those virtues, open-mindedness emerged as a teacher quality that changes teachers’ beliefs in positive ways. In this study, nearly no teachers from Turkey showed open-mindedness. The exam system and lack of PD opportunities for teachers are the main reasons.

7.2.1.3 Great teaching is an ability that can be fostered through CoP rather than being innate or developing individually

A fundamental finding from this study relates to applicability of CoP in educational settings. Wenger’s (1998) CoP is usually applied to apprenticeship models in industry and factories. This study indicates that teachers who participated in PD based on CoP approach fostered their professional knowledge, improved their practice and contributed to their character virtues. Similarly, Dillon and Manning (2010) considered that the development of science teachers is shaped by societal perspectives on science and the impact of educational policies on curriculum content and instructional methods. Dillon and Manning's (2010) study links teachers' practice to social dimensions. Outcomes showed that having a strong CoP plays a significant role in shaping and developing teachers' PCK and their teaching practice, especially in South Korea and Israel. In South Korea, Sung-Sook and Su-Mi's interviews indicate that both teachers contribute strongly to their community because they share and reflect on their experience with their colleagues through mutual engagement. This is a key indicator to generate great teachers and effective PD. In line with this point, Ilana and Irit as leader teachers in Israel contributed steadily and strongly to their community-based PD. Both teachers mentioned that collaboration along with reflection are features that promote a positive environment in which to develop teaching practice. If collaboration, sharing and reflective practice are improved between teachers, they get benefit from each other. All teachers have the potential to become a great teacher to some degree, as long as they keep attending CoP. According to Dillon and Maguire (2011), effective teachers consider positive and negative feedback. Their ability to learn from others' experiences as well as their own distinguishes them as the best teachers. Lave (1996) noted that the significance of communities of practice in characterising a great teacher. Teachers are more likely to be acknowledged as "great" when they actively engage in communities of practice, where their identities evolve in connection with other learners through collaborative activities. PD was conceptualised as an integral dimension of social practice by Lave and Wenger (1991) through participation and reflective practice in communities of practice.

All the countries in this study provided their teachers with PD; however, the focus is different in each case. For example, there is a tendency to implement bottom-up and experienced-based teacher training courses at both the preservice and in-service level in South Korea and Israel. Their tendency to make science education relevant needs to be investigated to develop well-structured PD for science teachers in general and chemistry teachers in particular. In South Korea, teachers who participated in Shingwaram presented topics relating to societal issues. Si-Nan for example prepared a presentation about global warming (see Section 5.4.3, Figure 5.25).

7.2.2 In what ways is the notion a 'great teacher' perceived in science teacher education in these four nations?

This study found that an understanding of great teachers and teaching are represented differently in teachers from England, Israel, South Korea, and Turkey. Teachers in England linked great teaching and great teachers to 'self-reflection' and the notion of a 'reflective practitioner'. Teachers in Israel consider great teaching as 'educating young minds', while a great teacher is an 'educator'. Teachers in South Korea linked great teachers to 'lifelong learning with passion and love about teaching' and the perception of being a 'lifelong learner'. Finally, teachers in Turkey associated great teaching with 'morality' and they saw a great teacher as someone who is a 'moral exemplar'. Although all four countries viewed those four components as characteristics of great teachers and teaching, they emphasised them differently. The differences between the four nations result from the ways they trained their teachers and the nations' conceptualisation of PD. The next section discusses the perception of great teaching and teachers in England.

7.2.2.1 England: Great teacher as a 'reflective practitioner'

Experience and hard work do not enhance knowledge and learning. Critical reflection plays an important role in shaping teachers' experience, practice, and improving performance as well as contributing to preparing more effective lessons (Dillon, 2011). In line with this, Elisa's critical reflection on her teaching makes her aware of the importance of raising scientifically literate students who need to be taught intellectual virtues (see Elisa's quotation in Section 5.2.3). In the teaching standards, the virtue of performing as a reflective practitioner has been accentuated in England (DfE, 2016). In this study, I noted that teachers who have a sense of reflectiveness on their teaching, created better learning environment for their students (see Seon-Mi's classroom observation). The white paper *Educational Excellence Everywhere* puts great emphasis on developing teachers who reflect on their practice (DfE, 2016). Thus, intellectual virtue requires reflecting on what should be done or what should not be done in the classroom while teaching a topic. Reflection is central to identifying whether teachers contribute to their students' understanding of science concepts. Reflection requires dialogue and communication with students, whether the particular topic is being taught or not. Teachers in England highlighted the importance of being critically reflective, which is one of the most significant characteristics of a great teacher (see chapter 5 for the outcomes for England). Elizabeth and Erik placed extra emphasis on why a teacher should be a reflective practitioner in their semi-structured interviews (see chapter 6). Reflection leads teachers to be responsive to their students' educational needs because today's classrooms are more dynamic and challenging than ever before.

Stake and Easly (1978) argued that content taught by teachers may have shortcomings in terms of bridging what they teach and the application of knowledge in daily life. In this regard, Jenkins (1994) thinks that science education should deal with real life issues. However, Longbottom and Butler (1999) claimed that real world is very messy and complex, so gaining scientific knowledge is not enough. In addition to knowledge, action needs to deal with daily life issues. Jenkins described this as a 'science education for action'. Eliot in his interview explains how he informs his instructions through collaborating with other teachers (reflection-on-action). Hence, great teachers should have effective reflective practice skills which achieve a balance between theory and practice. This reflective practice therefore contributes to learning new instructional strategies which transfer theory into practice.

Loughran (2002) paid attention to one potential risk associated with reflection is that if one's practice is solely focused on retrospective understanding, the subsequent forward-looking practice may lack necessary information or insights. Therefore, if a teacher wants his/her experience and teaching and learning to be meaningful and to become a great teacher, reflection on their teaching practice is essential. Reflective engagement fosters other intellectual virtues like critical thinking, reasoning, and curiosity. With the help of reflection, teachers may come to see clearly beyond 'who I am and what students expect from me'. The significance of this matter lies in the necessity of engaging in critical analysis and collaborative sharing of practices among colleagues in order to achieve effectiveness within CoP. Reflection therefore helps teachers expand the zone of proximal development in conjunction with colleagues. Erik states that being a mentor for other teachers helps him to reflect back on what he has done, and expands his knowledge expertise.

7.2.2.2 Israel: Great teacher as an 'educator'

The majority of the Israeli teachers who participated this study described themselves as an educator who motivated their students to be a good human being for a democratic society. Ilana wants to raise students who have good character and help other people in the society through science. Therefore, she takes students to care houses to take care of elderly people. Being an educator is a lifelong profession, which always supports student's intellectual, moral, and ethical virtues. Take Ivana as an example; in her interview, she placed more emphasis on students' moral and intellectual development. There is a correlation between intellectual and moral action of students. Idit, in her interview, states that teaching chemistry is not to make students more knowledge people. Rather, the role of teaching theoretical knowledge is to make students aware of societal issues and to help them to gain moral sensitivity about those issues. Irit says that teachers are not instructors; teachers are educators who care for their students in and out of school. In her interview, she said she opened her house to students who need special help, which shows that Irit is a role model who cares for and goes the extra mile for her students. In this regard, Lickona (1999) claimed that schools and teachers should be responsible for character education. I would say that one of the main duties of great teachers is to get students to develop empathy towards others. Therefore, great teachers should enable students to grasp the notion of treating others well.

7.2.2.3 South Korea: Great teacher as a 'lifelong learner'

Science teachers in South Korea provided students with opportunities to make science accessible to them. Findings from Sang-Cheol's laboratory observation showed that she conducted various hands-on activities which explained how oxidation-reduction reaction is relevant to our life. Sang-Cheol made sense of science activities, which enables her students to engage actively in her classroom. To achieve student engagement, Seon-Mi applied argumentation and dialogical teaching, which influenced students' scientific literacy and helped students gain critical thinking abilities. Scientific argumentation provides a place for practising various virtues and enables students to cultivate character traits like empathy, caring, responsibility, and willingness to act on socioscientific issues (Sharon & Baram-Tsabari, 2020).

Findings from the semi-structured interviews showed that teachers are attempting to apply particular strategies and extend their repertoire through attending a variety of learning communities. So-Yeon for example in an interview paid attention to the usage of advanced technological tools such as Arduino software coding for robotics. She said she learned about those instructions from attending a science contest, study group, and reading scientific articles. This active participation in communities and passion could be linked to the Confucian tradition. According to Confucius, attaining the virtue of doing good through learning and self-cultivation is the main purpose of a human being (Zhao, 2010). Si-Eun for example is enthusiastic about teaching and learning. In her interview, she stressed she that did lots of things such as preparing PD about radioactivity, attending other teachers' classes, and reading scientific articles.

This appetite for learning makes South Korean teachers in general more open-minded and willing to teach their subject matter excellently. For example, Se-Hoon's classroom observation showed that, although he used direct instruction in his class to teach thermodynamic, he said he put great effort into preparing the best class possible where all students were motivated to engage in the class. As he is willing to teach the best class, he questioned his philosophy of teaching in his interview (see Section 5.4.4). Open-mindedness is one of the most important intellectual virtues which aims at fostering knowledge and understanding (Taylor, 2016). Therefore, being open-minded is central to being a lifelong learner. Open-mindedness, as an intellectual virtue, encourages teachers to enhance the virtue of lifelong learners. Open-mindedness as a mean between closed-mindedness and credulity plays an important role in deciding whether scientific knowledge should be accepted as it is or whether it needs to be judged appropriately before the knowledge is transferred to students. In their interviews, teachers such as Seon-Mi, Se-Yeon, Sung-Sook, Si-Eun, Su-Mi put emphasis on scientific literacy. They believed in raising scientifically literate students who can distinguish between knowing what is right and wrong.

7.2.2.4 Turkey: Great teacher as a 'moral exemplar'

Teachers in Turkey attempt to implement traditional methods such as lecture-style teaching which enable teachers to dominate the classroom. In their classroom observations, it could be seen that Turgut and Tolga used a didactic teaching style with limited interaction with students. The lack of interaction between teachers and students generated monotonous classrooms in which students were passive listeners. However, Türkan in her classroom applied constructivist and student-centred instruction to explain organs to students in her laboratory.

Turkish science teachers' beliefs are neither teacher-centred nor student-centred. Although the national educational standards in Turkey want teachers to implement modern beliefs (beliefs based on constructivist learning, student-oriented classroom structures, and an orientation towards more general educational skills, including scientific literacy for all), teachers seem to be closer to practising traditional beliefs (transmission-oriented beliefs of learning with a focus on rote memorisation of subject-matter knowledge) (MoNE, 2013). Tanyeli for example said in her interview that she did not do experiments or apply student-centred instruction. The findings here show a dichotomy between what the standards say and what teachers perform in the classroom. Studies in connection with chemistry teachers' beliefs in Turkey showed that teachers follow neither a constructivist view nor a traditional view, but fall somewhere between those domains (Boz & Uzuntiryaki, 2006). Al-Amoush, Usak, Erdogan, Markic, and Eilks (2013) reported that chemistry teaching is dominated by more teacher-centeredness and shows that the relationship between teacher and students is vertical. Freire calls this pedagogical approach the banking model of education (Freire, 1970). In this model, teachers tend to make students passive listeners and cut communication and dialogue. So, learning from each other is nearly impossible.

The semi-structured interviews with the Turkish teachers indicated that teachers in Turkey believed they were moral exemplars who are responsible for students' moral development. Mischinski and Jayawickreme (2019) discussed the idea that being a moral exemplar had the potential to lead people to live good lives and gain practical wisdom. Tuğçe for example said she promoted free classes at the weekend for her students (those from disadvantaged backgrounds). Turgut highlighted the notion that a teacher should provide knowledge and cultivate moral character.

7.2.2.5 Conclusion: Great teacher

In the literature, high-quality teaching has been defined. Some researchers developed a formula for high-quality teaching and teaching. As it is discussed in Chapter 1, quality is associated mainly with a competency-based approach. What it means is that teachers should have competencies like good CK and PK as well as PCK. A review paper conducted by the ACER proposed an equation for quality. It is a combination of competencies and productive behaviours, and it works through the catalytic impact of personal attributes (Bahr & Mellor, 2016). According to the review, the elements that bring about excellence include personal characteristics such as setting high expectations of all learners, kindness, fairness, humour, and a general good approach toward teaching.

Q= (competencies + productive behaviours) X personal attributes

Flores (2019) linked teacher quality to leaders of learning in an amalgamation of motivation, innovation, committed professionalism, and resilience. The ACER and Flores (2019) put more emphasis on a person's character qualities and their contribution to quality teaching. Arthur et al. (2015), which discussed in Chapter 1 and 2 supported Flores's (2019) findings. Finally Praetorius, Klieme, Herbert, and Pinger (2018) introduced a framework which contained three basic dimensions of teaching quality. This framework covers generic aspects of classroom teaching, that is, classroom management, student support, and cognitive activation. All this research on what makes for high-quality teaching contributed to our knowledge. However, how those qualities of teachers do contribute to teachers' practice still needs to be investigated. This study provided a new lens to define great teaching. Greatness in teaching is perceived as allowing teachers to establish mutual understanding and allowing them more space to draw upon intellectual, performance, moral, and civic virtues through the lens of practical wisdom. This practical wisdom seems feasible through virtue-based teaching that focuses on wise-decision making, reflective practice, educational appropriate judgement, PCK, PB&V and passion. Teachers are responsible for enabling students to be knowledgeable persons while transmitting moral values as a moral agent and exemplar (Carr, 1993; Jackson, Boostrom, & Hansen 1993; Sockett, 1993). This study defines great teaching with the focus on gaining practical wisdom, which shapes and activates teachers' personal and professional qualities (see Chapter 6, section 6.3.1.1 and 6.3.1.2) to prepare and deliver best class possible for students. Among these attributes, the four case study countries emphasised being reflective on teaching practice, being a life-long learner, being responsible to students' whole-person development, and being a moral model, all of which emerged as distinguishing characteristics of a great teacher (Figure 7.1).

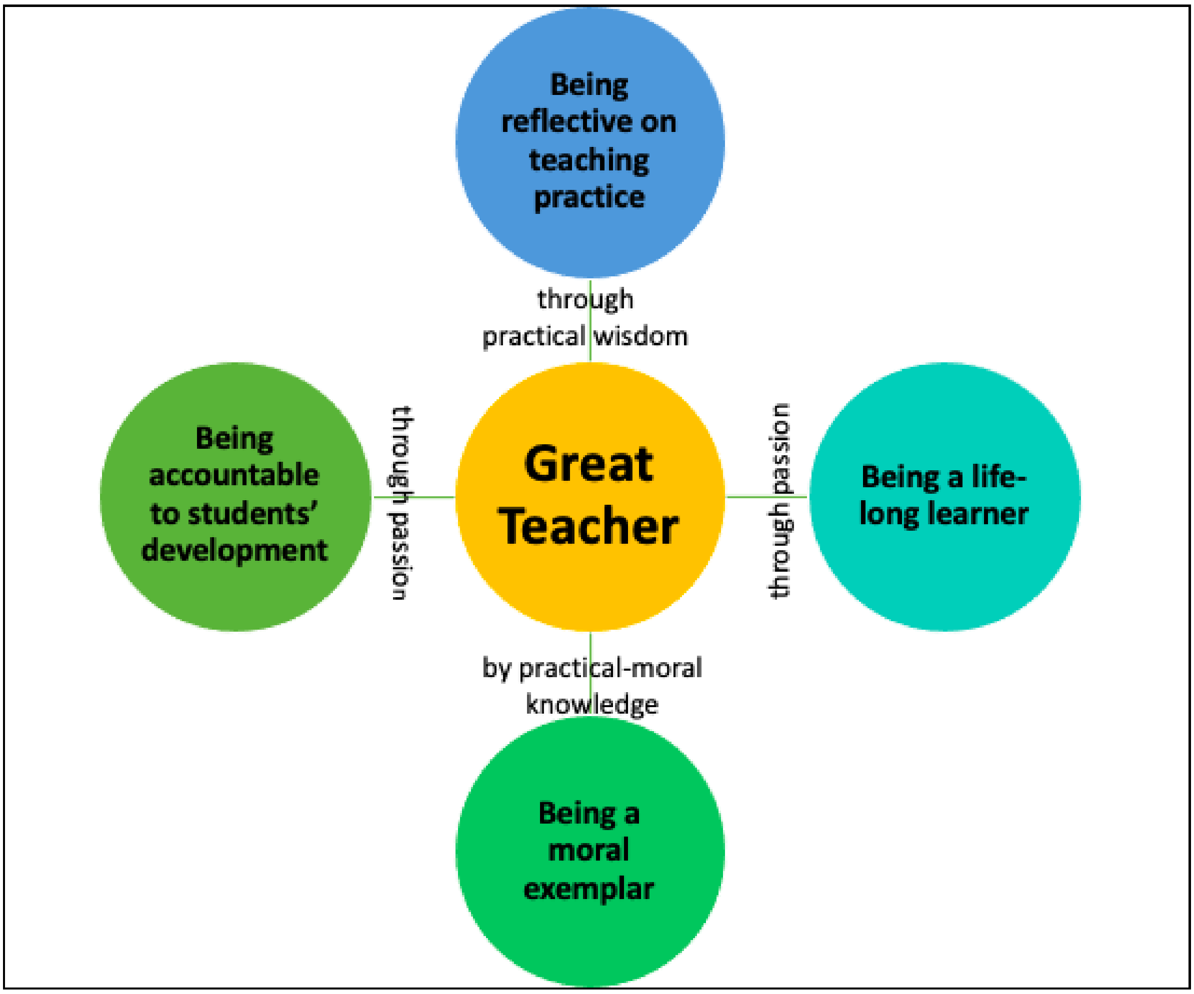


Figure 7. 1 The amalgamation of the great teacher

Figure 7.1 gives a thorough explanation of the complex aspects of being a great teacher. It emphasises the idea that teaching greatness is a product of a combination of several crucial traits and attributes rather than being determined by a single one.

The value of reflection and practical insight is highlighted by the first pathway in the illustration. Great teachers are those that are always introspective, learning from their teaching experiences, and evaluating their methods. When talk about practical wisdom, it mean having a thorough understanding of educational practices and being able to use that knowledge in the classroom (Carr, 1993). Great teachers consistently improve their teaching strategies with the goal of improving student learning outcomes through this reflective process and practical wisdom.

The value of passion in teaching is emphasised by the second pathway. Along with being extremely informed, great teachers have a strong passion for their subjects and the development of their students. They adopt a mentorship and advocacy role, exhibiting a deep dedication to their pupils' academic pursuits. They go above and beyond the typical bounds of teaching because of their passion, which motivates them to take responsibility for their students' growth on both an intellectual and personal level (Jackson, Boostrom, & Hansen 1993).

Character and moral knowledge are highlighted in the third pathway. Excellent teachers set an example of moral behaviour and moral principles for their students. Their ability to make morally correct decisions is based on their practical moral knowledge, which guides their behaviour (Sockett, 1993). They teach pupils valuable life lessons while advancing their subject matter knowledge and fostering their moral character.

The trait of being a lifelong learner is highlighted in the fourth pathway. With the knowledge and teaching strategies they already possess, great teachers never settle. Rather, they continue to have a passion for lifelong learning (Carr, 1993). Since learning is their passion, they are driven to increase their knowledge and hone their pedagogical abilities for the benefit of their pupils.

The idea that great teaching is a complicated and multidimensional endeavour is beautifully illustrated in Figure 7.1. Great teachers are known to embody a variety of diverse traits, such as reflection, passion, moral exemplar-ship, and a dedication to lifelong learning. A great teacher is someone who integrates these qualities into their teaching, so providing their pupils with an engaging and enriching educational experience.

7.2.3 How and why (if at all) do teachers gain wise education judgment/practical wisdom?

Understanding how teachers develop their practical wisdom, along with the variation in science teachers' practice with this approach, is critical for the study of science teaching and learning. This is particularly important as, despite decades of research, PCK and beliefs are not yet widely incorporated into science classrooms and science teachers' practice (Kind, 2015, 2019; Neumann, Kind and Harms, 2019). One of the reasons for the current lack of understanding of practical wisdom in science education may be a lack of familiarity with how science teachers develop and evolve their educationally wise judgment ability. Therefore, this study aimed to add to a better understanding of how science teachers developed their practical wisdom over time and scaffolded this approach throughout CoP.

7.2.3.1 Supporting teachers' practical wisdom in education

The exploration of 'great/effective/excellent teachers' in various literary works predominantly focuses on the analysis of their competencies and qualities. These works often present a compelling argument by formulating an equation or formula that encapsulates the essence of exceptional teaching (refer to Chapter 1 for further details). Teachers, as exemplified by Claxton's work in 1990, are expected to possess a remarkable level of creativity and imagination. Additionally, their pedagogical content knowledge (PCK) and ability to deliver high-quality instruction, as highlighted by Kind and Chan in 2019, are crucial aspects of their professional repertoire. Furthermore, teachers are expected to demonstrate productive behaviours, as emphasised by Bahr and Mellor in 2016. The significance of the social dimension of learning has been woefully overlooked, despite its immense potential to greatly enhance one's journey towards becoming an exceptional teacher. Drawing inspiration from the seminal works of Biesta (2012) Kind and Chan (2019) and Wenger (1998), this study embarks on a captivating exploration into the essence of greatness in teaching. Through the perspective of practical wisdom, teachers are able to gain a deeper understanding of how to navigate unforeseen circumstances and enhance their teaching practice. This concept serves as a valuable tool for educators, enabling them to seamlessly integrate their professional growth within their school environment. By fostering learning communities, teachers can actively contribute to the advancement of pedagogical practices.

Four nations in this study contributed to their teachers' PD. Emphasis has been put on teacher quality in four nations. Through document analysis, three qualities namely CoP, PCK, and PB&V emerged as important teacher qualities that have potential to make teachers great (see Chapter 3). Policy documents of England, Israel, South Korea and Turkey indicated that nations took initiatives to develop teachers PCK and PB&V through PD (see Chapter 3). The findings of the study showed that supporting teachers' practical wisdom through PD paid little attention. In England, teachers paid much more attention to develop their professional knowledge with a focus on SK. Teachers in England, thus, prefer to attend subject-specific PD, which lacks of the elements of PB&V such as moral, or civic dimensions in the PD sessions. The result of the study is compatible with Arthur et al. (2015) study. They noticed that teachers' in England and Wales had difficulty in applying to moral aspects of teaching. In Israel, PD observations and interview with teachers indicated that as in England PD of teachers based primary on developing teachers' SK. However, continuous participation to community-based PD at Weizmann helps teachers to develop some virtue characters such as sharing, social intelligence, leadership. Ilana, Idit and Irit, for example, are experienced leader teachers with over 25 years teaching experience. What they have commonly highlighted the fact that social interaction with other teachers in community-based PD helped them develop some aspects of practical wisdom such as intellectual action, mutual understanding (see Chapter 6, Section, 6.3.1.1). In South Korea, teachers follow at least one PD. Observations in PD indicated that PD sessions focus on SK and hands-on activities and pay attention to development of teachers' civic, moral and performance virtues which are important for developing practical wisdom. The teachers in South Korea developed their practical wisdom in a varied manner resulted from their beliefs, passion and love about teaching. Seon-Mi, for example, is an experienced master teacher. In her interview, she highlighted that caring, fairness, honesty and love of learning make teachers different. These character strengths were observed when she was teaching. She created a corner called 'voice of student' in the classroom. This encouraged students to reflect their ideas comfortably. She took care of their students' thoughts. She used different instructional strategies such as modelling, storytelling, experiment, and direct instruction. In her interview, she said she learnt those instructions through Singwaram, where she has been attending since 1993. Shared repertoire, mutual engagement with other teachers and joint enterprise helped Seon-Mi to gain different perspective and made her great teacher. The study discovered there is potential for tailoring professional development to meet the unique needs of individual teachers, while promoting mutual engagement and collaboration. In Turkey, except couple of teachers (Turgut, Tuba, Tuğçe), majority of teachers did not participate in continuous PD. Instead, they participated in in-service training courses provided by MoNE twice a year (beginning of the academic year and end of the academic year). The poor participation to PD in Turkey resulted in not gaining practical wisdom, which develops through social interaction.

Showing aspects of practical wisdom influences teachers' practice, as seen Seon-Mi, Ilana and Turgut's classes. Teachers who show practical wisdom in their practice also show concerns about their students' meaningful learning and whole person development. Students' learning can be improved utilising flipped learning, argumentation and dialogical teaching (Seon-Mi and Ilana were adopted in their classes). These instructional strategies encouraged students to engage classroom discussion and contributed to group discussions. To achieve students' engagement, Ilana, for example, apply argumentation and dialogical teaching, which influenced students' scientific literacy and helped students gaining critical thinking abilities (asking questions). Scientific argumentation, for example, is providing a place for practicing various virtues and enable students to cultivate character traits like empathy, caring, responsibility and willingness to take action on socio scientific issues (Sharon & Baram-Tsabari, 2020). However, teachers in Turkey implemented traditional methods which enable teachers to dominate the classroom. Lack of interaction between teacher and students, generated monotonous classrooms in which students were passive listeners (see Tolga's classroom). One possible interpretation of these differences in teachers' practice is that as teachers attended collaborative and interactive teacher communities, they gained instructional strategies, pedagogical reasoning and improved classroom dialogue. Another possible interpretation of these difference results from experience. Annas (2011) and Schwartz and Sharpe (2010) argued that cultivating and fostering practical wisdom requires time, including experience, practice, and reflection all playing important roles to be a great teacher. Similarly, this study revealed that as teachers spend time in teaching, they valued character virtues more than novice and less experience teachers did. Leader teachers' PB&V in Israel (Ilana, Ivana, Irit and Idit, for example, paid attention to fairness, accountable to all students than those of less experienced teachers who focus particularly on delivering SK.

7.3 Contributions to knowledge and implications of the study for future research

This research contributed to science education literature in three ways. This research raised awareness the importance of CoP, practical wisdom, and the conceptualisations of great teachers. The next section discuss why the nature of PD programme should be reviewed.

7.3.1 The nature of PD programmes should be changed

The findings in this study (see chapters 5 and 6), prompt several suggestions for developing great teachers in Turkey and other nations. First, the literature review and document analysis revealed that community-based learning programmes, regardless of their generic or subject-specific orientation, may help support teachers' PCK and PB&V to some extent. The traditional nature of top-down PD programmes should be replaced with programmes run by teachers themselves. Both Israel and South Korea take advantage of PD programmes run by teachers. Both countries tended to apply a cascade model of PD to generate more great teachers who have strong connections with each other. Those programmes influence teacher's beliefs and other virtue skills. PD programmes influence teachers' cognition, which impacts teachers' practice (Richardson, 1996). The poor conceptualisations of teachers' beliefs and practical wisdom and misunderstanding around those concepts have resulted in the establishing of poor PD programmes. Great teachers should be developed through community-based PD that employs the lens of practical wisdom.

The first implication of this study is therefore that the nature of PD programmes should be designed to support teachers' understanding of virtue characters and practical wisdom. So far, including Darling-Hammond in USA and other researchers such as Cordingley in England explained the features of PD, but did not mention how those features influenced teachers' practice. A fundamental learning from this study is related to development of teachers' performance and civic virtues that impact on teachers' practice. Especially in South Korea, community-based PD enabled teachers to learn how to apply some civic and performance virtues in practice. No other countries in this study actually paid attention to develop teachers' civic and performance virtues. Three nations Israel, Turkey and England focused on developing teachers' CK. Developing teachers' CK gives teachers more knowledge about the subjects that they teach. However, as in South Korea, if PD contains elements focusing on developing teachers virtues, makes passionate teachers and moral exemplars who has practical-moral knowledge. Many PD programmes focus on enhancing teachers' SK and PK. However, little attention has been paid to designing virtue-based PD to foster teachers' practical wisdom and educationally appropriate judgment. Establishing a virtue-based PD programme is essential to cultivate teachers' professional character virtues such as their intellectual, performance, moral, and civic virtues. Teachers who present those virtues effect on their usage of high-quality instructions in classroom settings (see Eliot, Erik, Ilana, Ivana, Seon-Mi, Sung-Sook, and Turgut's reflective interviews). Teachers who engaged in community-based PDs for example demonstrated strong general pedagogic knowledge, which Shulman referred to as classroom management and organisation, and knowledge of educational ends, purposes, and values (Shulman, 1987). Practical wisdom in classroom settings for example enable teachers to manage unexpected issues excellently and to create a bridge between professional knowledge of teachers and their professional qualities through PD (see Section 5.4.1 So-Hyun' quotations and So-Heon's PD session; Section 5.4.3 Si-Nan's PD session). Cultivation of performance virtues in PD programmes plays a significant role in conceptualising teacher interest, teacher motivation, and teacher self-efficacy. Both Seon-Mi and Sang-Cheol use collaborative and student-based instructions like flipped learning and constructivist style in their classrooms. Both teachers show self-efficacy, which engages and motivates students actively in the classroom. Bryan, Glynn, and Kittleson's (2011) study supports my study findings. They found that teachers who used social modelling and collaborative learning activities help foster students' motivation.

Intellectual virtues are an essential part of decision-making and appropriate judgement and lead teachers to take the right action at the right time through wisdom (Santos, Huynh, & Grossmann, 2017). Intellectual virtues are a central element in establishing virtue-based PD. The best way to help teachers to achieve the critical and reflective nature required of their profession is made possible through cultivating intellectual virtues. Having those virtues enables teachers to pursue what to do and what not to do in the classroom. Intellectual virtues therefore play a significant role in enhancing practical wisdom, which is reflective and has an influence on personality qualities. This study indicates that not enough attention has been paid to intellectual virtues in PD activities in general. This lacuna gives rise to poor decision-making and judgement when teachers face unexpected situations in the classroom. To some extent, South Korea and Israel managed to put intellectual virtues into practice through taking the cascade model approach in PD activities (see Section 5.4.1 So-Hyun and So-Heon's PD in South Korea; see Section 5.3.1 Ilana's PD). Implementation of virtue-based PD activities results in changing teachers' intellectual manner, which is central to having practical wisdom (see So-Yeon and Su-Mi's interviews in Section 5.4.3 and 6.3.3.1). Gaining practical wisdom is essential to handle fundamental settings of classroom teaching using the pragmatic approaches (Cooke & Carr, 2014). Therefore, subject knowledge-based PD and PCK-based PD programmes are not enough to ensure teachers gain practical wisdom. Virtue-based PD provides teachers with expert knowledge, which is crucial to developing alternative viewpoints regarding how to create authentic learning environments for students.

7.3.2 Practical wisdom in science teaching should be implemented

This study gives insight into nations like Turkey, which are ambitious to achieve great science education teaching and learning standards. Little attention has been paid to students' gaining the perspective of global citizens and providing students with opportunities to engage with science (Goodwin, 2021). Character virtues therefore should be at the centre of science education to help learners to deepen their understanding of sociocultural consciousness, which helps cultivate global mindsets based on moral (Carr, 2006; Curren, 2014) and intellectual (Baehr, 2013; Kristjánsson, 2015) virtues, both of which contribute to civic and performance virtues through great teachers. Another fundamental finding from this study is related to developing teachers' practical wisdom. As Biesta (2015) highlighted difference between great teachers and others is based on their judgement ability to apply to their teaching. This point impacts the ways teachers deliver topics to students. Teachers in their interviews highlighted that chemistry topics do not change. The principles of chemistry are the same everywhere. What does change teachers' beliefs about how to deliver topics in the best way possible to promote students' understanding of science. Classroom observations in this study showed that teaching chemistry requires judgement about what to use, why to use and how to use instructional strategies which are shaped by teachers' beliefs and character virtues as well as the education system. In Turkey, teachers focused mainly on delivering theoretical knowledge and they believed that doing practical work in the laboratory is a waste of time for students because practical work does not influence students' grades at the university entrance examination. However, in Israel, every student majoring in year-12 chemistry must study at least one industrial case study as part of the matriculation exam (Hofstein & Kesner, 2006). Industrial chemistry learning materials, in addition to instructional techniques, were developed for Israeli high-school chemistry education, placing greater emphasis on applied chemistry in the chemical industry. In Israel, teachers focused on both delivering theoretical knowledge and practical work.

Practical wisdom-based science teaching, which is mainly concerned with the practical-moral dimensions of teaching, helps students to be motivated and engaged with learning science in effective ways. Ilana in this study for example said she encouraged her students to do experiments and participate in volunteer activities. To become a great teacher, being a person who has good character traits is a priority. It is as significant as mastery of one's subject and pedagogic knowledge as well as high-quality instructions for teachers. This study shows that teachers with high integrity and fairness communicated and motivated their students better when they taught topics, which in turn affected students' engagement in the classroom. Song-Sook and Snag-Cheol in South Korea went to a community centre with students to help elementary school students who are from disadvantaged backgrounds. Both teachers have a moral character which supports society. Teachers who demonstrate moral reasoning, intelligence, and judgment orchestrate their classrooms excellently. Seon-Mi for example used flipped learning; Ilana used argumentation in her classroom. Both instructional strategies enable them to create an environment where students engage actively. Those who have moral virtues create a learning environment where students enjoy and are motivated to learn science.

Moral virtues are central to forming civic virtues, which are related to generating responsible citizens with global mindsets (see quotations from Seon-Mi, Sang-Cheol, Song-Sook, Idit, Irit, Ivana, and Tuba). Teachers are not confined to a particular society anymore. Great teaching thus includes the cultivation of civic virtues. The ultimate goal of education from an Aristotelian viewpoint is to achieve human flourishing (Kristjánsson, 2015). Raising responsible students who take care of others is important if people are to pursue a better life as a community. Teachers as moral exemplars pave the way for developing practical wisdom and their students' ability to lead a good life, which in turn affects classroom and school culture.

7.3.3 The conceptualisations of teachers' qualities should be reconsidered

Teaching quality and teacher quality have emerged as an international concern. For example, Cochran-Smith in her special issue paper *Exploring teacher quality: International perspectives' questions international understanding of teacher quality*. Defining teacher quality and teaching quality is not straightforward, as the concept of quality varies in local and national contexts as well as global contexts (Cochran-Smith, 2021). Another article entitled *Defining teacher quality around the world* by Darling-Hammond examined high-achieving countries i.e., Australia (Victoria and New South Wales), Canada (Alberta and Ontario), Finland, China (Shanghai), and Singapore. The results showed that teacher quality is an amalgamation of content and pedagogy to which contributes students' needs i.e, academic, emotional and non-emotional (Darling-Hammond, 2021). These studies showed that there is a gap in the conceptualisation of what teacher qualities mean and comprise at both national and international levels. Although this comparative case study of England, Israel, South Korea, and Turkey gives insights into and comprehension of great teacher at a national level, the gap still prevails among other countries. This study added a teachers' practical wisdom as a new dimension for rethinking teacher qualities that make great teacher. This addition creates a shift whereby teachers are responsible for navigating students' learning for the whole person. The OECD Learning Compass 2030 introduces a learning framework which prioritises the need to improve students' well-being in unfamiliar and unexpected contexts (OECD, 2018). This learning requires practical wisdom, which promotes students' abilities to become a wise person. Having academic qualifications (good SK, good PCK, and delivering high-quality instructions) does not seem to be sufficient when it comes to helping students to become a whole person. Attention should be paid to teacher character traits such as moral intelligence, ethical sensitivity, wise decision-making, and judgement when designing teacher training and development courses.

7.4 Limitations of the study

A major limitation of this study was the Covid-19 pandemic that began in early 2020. Due to the rapid spread of the pandemic to one of the countries where I intended to collect data sets, I could not perform classroom observation, focus group interviews, and PD activity observation in England. Another limitation was the sample size of the study. Forty volunteer teachers in four nations contributed to the study. Consequently, its findings cannot be generalised to a wider population. The purposeful selection of PD activities in South Korea and Israel may not be representative of the whole country. It would have been better to collect data from different PD courses to represent to wider population. Classroom observations could have been extended to all teachers (N=40) rather than just nine teachers. Furthermore, my thoughts about practical wisdom might not actually be a correct view. They are just my interpretation of the literature. I interpreted the literature in a particular way and the strong emphasis I put on certain elements might not have been somebody else's emphasis. Therefore, the potential for research bias was likely. As a former science teacher who attended PD activities in Turkey, my home country, bias might have occurred during my classroom and PD activity observations there. To mitigate research bias, I did not get involved in the activities. Triangulating the data sets and conducting a systematic review helped to reduce research bias.

Despite the fact that this study contributes significantly to teacher quality and teacher development through case study approach, a number of limitations were identified related to methodological decisions and analytical techniques. In my study, I argued that knowledge is socially constructed. Therefore, I did not believe that the interpretations, explanations, and connections made during lesson observations, PD observations and interviews accurately represented the cases studied. Using multiple data generation methods did not always result in a strict triangulation of findings. However, the interconnected observations (lessons and PD activities), interviews with teachers, focus groups, along with document analysis helped me cross-check and expand my interpretations. I acknowledge that data collection methods have limitations and may not accurately reflect the thoughts and practices of all participating teachers. I could have explored different PD activities, including those provided different opportunities to compare and contrast their methods in different science contexts.

Moreover, the majority of teachers who participated in my own study recognised that community-based professional development might have a substantial impact on their practice through shared repertoire, cooperation and mutual engagement. However, I was only able to observe this feature in the community, not at schools. Reflective interviews and focus groups revealed that teachers want to extend elements of CoP throughout the entire science department in their schools. The questions were designed to identify practical wisdom and components of great teacher in teachers' chemistry teaching practices, thus they may have limitations. To ensure the validity of case study findings, I used recommended approaches such as extensive description (Guba, 1981) and data triangulation (Creswell & Miller, 2000). I use the term "relatability" to describe how information learnt in one context can be applied to multiple contexts or time frames (Bassey, 1999). The next section discusses recommendations for future research.

7.5 Recommendations for future research

This study raises awareness about the notion of practical wisdom and the existence of great teachers in science classrooms. Therefore, the first recommendation for future work is to look at the findings of this study. Great teacher, so far, is associated with the knowledge domain of teaching. This study shows that practical wisdom and its relation to great teaching have not been investigated yet. The practical wisdom, which comprises PCK, PB&V, P-MK and passion, should be investigated in different educational contexts to ascertain if other researchers reach the same results. Although some empirical studies have been conducted to uncover the relationship between good teaching and morality, little attention has been paid to investigating the effect of the development of practical wisdom, performance, intellectual, and civic virtues on teacher practice. Attempts to investigate how those virtues influence students' understanding of science in different context and settings should be done by doing more case studies. The findings of this study indicate that four different aspects of a great teacher, namely a reflective practitioner in England, an educator in Israel, being a lifelong learner in South Korea, and a moral exemplar in Turkey should be validated in different nations and investigated to see if culture has an influence on becoming a great teacher. It is important to investigate the aspects of practical wisdom in detail to ascertain whether other images of practical wisdom match with those found in this study. Researchers should use different methods and methodology to investigate the notion of practical wisdom. Investigating the notion of practical wisdom through comparative case study was time-consuming and definitive.

7.6 Personal gains

Through conducting this study, I have developed different kinds of skills and abilities which have contributed to my becoming an independent researcher. Each supervision with Professor Vanessa Kind made me more confident about deciding what I should do for the next steps of the research. During the last four and a half years at Durham, I have attended many conferences and workshops, which enabled me to discuss my ideas with researchers from different parts of the world. Attending research communities enabled me to judge my work from an international perspective, as I encountered globally respected researchers who are working in areas closely related to my thesis. Coming together with other colleagues with shared values in teaching secondary science contributed significantly to my knowledge of teaching science and the ways in which great teachers should be developed. The nature of my study meant that I was able to work collaboratively with researchers and teachers in South Korea and Israel. As I gained experience of working in a collaborative environment and gaining different insights from other cultures on teacher PD, I became more confident and self-reflective on my work. I think that my past experience of working in different contexts (data collection from four different nations) and the skills that I have gained during my career will open up new opportunities for me in the academic field.

7.7 Conclusion

According to the European Commission, great teaching is defined as allowing pupils to attain their goals such as "successful learning outcomes, by developing the knowledge, skills, attitudes and values that learners need in order to realise their full potential both as individuals and as active members of society and the workforce" (European Union, 2014, p. 1). Darling-Hammond (2013) argued that while the context of the teacher has a considerable influence on teaching quality, it is a consequence of teacher quality that includes teachers' knowledge, abilities, and attitudes. This study, therefore, investigates the perceptions of great teacher in four case study nations. The results of the study showed that practical wisdom is an vital component of being a great teacher and CoP plays a critical role in developing teachers' practical wisdom.

This study contributes to a growing body of knowledge by opening new perspectives on and (re)thinking about great teachers in science teaching and the definition of a great teacher by putting emphasis on the notion of practical wisdom. High-achieving countries and others share common challenges around increasing the number of great teachers they employ, including getting the right people to become teachers, developing them into efficient instructors, and ensuring the system's ability to deliver the best possible instruction for every child. Moreover, high-performing nations are implementing systemic interventions that effect change at the school level. Those interventions do not impact on improving teachers' practical wisdom which influences teachers' wise decision-making, and educationally appropriate judgement. The notion of practical wisdom should be considered by nations that achieve excellence in teacher education as a means of developing great teachers when implementing new policies in science education. Therefore, this study found that the notion of practical wisdom should be implemented in science teacher education.

The integration of the individual and their social structures aids in the development of their practical wisdom. Learners' practical wisdom is central to learning and can be shaped by others in various communities through their participation and mutual engagement in collaborative work. Therefore, a well-developed CoP including the element of mutual engagement, shared vision and shared repertoire has the potential to develop more great teachers. Learning from this study is partly applicable to the Turkish teacher education system. The examination system is the most significant barrier, which directly impacts teachers' beliefs about teaching science and thus their professional development. Some changes at a systematic level should be made. That is why nations were chosen from different development levels which could guide Turkey to generate great teachers, and thus develop the high-achieving system.

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Appendices

Appendix 0: Examples of documents and documents analysed

Documents selected for England:

Document Title	Description and Source
The Importance Of Teaching The Schools White Paper 2010	A white paper from 2010 by the Department for Education (DfE) outlining the importance of teaching in schools.
Teachers’ Standards guidance for school leaders, school staff and governing bodies	A document issued by the Department for Education (DfE) in 2011, providing guidance on teacher standards for school leaders, staff, and governing bodies.
Teachers in England’s Secondary Schools: Evidence from TALIS 2013	A document published by the Department for Education (DfE) in 2014, presenting evidence from the Teaching and Learning International Survey (TALIS) 2013 with a focus on secondary schools in England.
Educational Excellence Everywhere	A document from 2016 published by The Williams Lea Group, discussing educational excellence in England.
Strengthening Qualified Teacher Status and improving career progression for teachers: Government consultation response	Published by Crown Publishing in 2018, this document presents the government's response to strengthening qualified teacher status and enhancing career progression for teachers.
Opportunity for all Strong schools with great teachers for your child	A 2022 document from the Stationery Office in London, outlining the opportunity for strong schools with great teachers in England.

Documents selected for Israel:

Document Title	Description and Source
A New Horizon? The Effect of a National Education Reform on Students Achievements and the Academic Environment	This report authored by Reingewertz and Shany (2022). This document informs how new horizon reform effects on teachers’ practice and their development which impact on student achievement
An overview of Israel’s education system and its impact	Published in 2017 by Ben-David and Kimhi, this document provides an overview of Israel's education system and its impact.
Trends in International Mathematics and Science Study 2015	A source from the National Authority for Measurement and Evaluation in Education (RAMA) in 2017, focusing on Trends in International Mathematics and Science Study (TIMSS) 2015 in Israel.
Secondary Students’ Evolving Relationships and Connections with Israel	A 2022 publication by Reingold, discussing secondary students' evolving relationships and connections with Israel.

Document Title	Description and Source
Proven success in Israel education – Context, sources, and perspective	Authored by Stein in 2020, this document discusses proven success in Israel education, exploring context, sources, and perspective.
The Israel educator: An inquiry into the preparation and capacities of effective Israel educators	A research brief from 2013 by Sinclair, Solmsen, and Goldwater, focusing on the preparation and capacities of effective Israel educators.
Attracting, Developing And Retaining Effective Teachers	A document from Zuzovsky and Donitsa-Schmidt (2004) discussing the attraction, development, and retention of effective teachers in Israel.
The Relationship between Professional Environmental Factors and Teacher Professional Development in Israeli Schools	A 2022 document by Hilel and Ramírez-García, examining the relationship between professional environmental factors and teacher professional development in Israeli schools.

Documents selected for South Korea:

Document Title	Description and Source
Education For The Future	A publication by the Korean Educational Development Institute (KEDI) in 2015, focusing on education for the future in South Korea.
Education for the Future	Another publication by KEDI in 2016, continuing the discussion on education for the future in South Korea.
A window into Korean Education	A 2017 document by KEDI offering insights into Korean education.
“It's always more difficult than you plan and imagine”: Teachers' perceived difficulties in introducing the communicative approach in South Korea	An article by Li from 1998, discussing teachers' perceived difficulties in introducing the communicative approach in South Korea.
The influence of the Programme for International Student Assessment on educational governance situated in the institutional setting of South Korea	Authored by Kim and Choi in 2023, this document explores the influence of the Programme for International Student Assessment (PISA) on educational governance in South Korea.
The fourth industrial revolution, knowledge production and higher education in South Korea	Published by Jung in 2020, this document examines the fourth industrial revolution, knowledge production, and higher education in South Korea.
Teacher Training and Development Policy in Korea	A document from 1997 by Yun, discussing teacher training and development policy in South Korea.
New Education policies and practices in South Korea	A document from UNESCO Bangkok in 2017, discussing new education policies and practices in South Korea.

Documents selected for Turkey:

Document Title	Description and Source
Teacher Strategy Document 2017-2023, Ankara: Turkey	A document from the Ministry of National Education (MoNE) in 2017, outlining the Teacher Strategy Document for 2017-2023 in Turkey.
Identification of In-Service Teacher Education Policies in Turkey and Investigation of Their Reflections on Practices	Authored by Abide and Gelisli in 2021, this document identifies in-service teacher education policies in Turkey and investigates their reflections on practices.
Dünya'da ve Türkiye'de Hizmetiçi Eğitimler: Kurumsal ve Akademik Hafıza (Kayıpları)mız (Tedmem) (Turkish)	Cultivating great teaching through in-service teacher training ; perspectives and challenge
General competencies for teaching profession - MEB	A document from Ankara in 2017 by the Ministry of National Education (MEB), outlining general competencies for the teaching profession in Turkey.
The Outlook on Education in Turkey 2017: Monitoring and Evaluation Report	A report from from the Egitim-Bir-Sen Centre for Strategic Research, highlighting teachers' needs for becoming a great teacher.
Improving the education system and its outcome in Turkey 2011	The importance of teachers in education system and their professional development by McKinsey 2011 report

TALIS Documents by OECD [focus on England, Israel, South Korea and Turkey]

Document Title	Description and Source
TALIS 2008 Results Creating effective teaching and learning environments: First results from TALIS, 2008	Comparative perspective in teaching and learning, focusing on South Korea and Turkey
TALIS 2013 Results An International Perspective on Teaching and Learning	High-quality Teacher Professional Development and classroom teaching practice evidence from Israel, South Korea, and England
TALIS 2018 Results Teachers and School Leaders as Lifelong Learner (Volume I)	Perspectives from England, Israel, South Korea and Turkey on how to become a highly effective teacher.
TALIS 2018 Results Teachers and School Leaders as Valued Professionals (Volume II)	Perspectives on teaching as a profession from England, Israel, South Korea and Turkey

OECD educational policy outlook [focus on England, Israel, South Korea and Turkey]

Document Title	Description and Source
Educational policy outlook 2015: Making reforms happen (England)	Balancing accountability and improvement in schools through multi academy trusts
Educational policy outlook 2015: Making reforms happen (Israel)	The New Horizon Programme aims at developing great teachers through community-based professional development
Educational policy outlook 2015: Making reforms happen (South Korea)	Korea launched the National Teacher Professional Development and Evaluation System (NTPDES) (2010) to improve teacher effectiveness.
Educational policy outlook 2015: Making reforms happen (Turkey)	The Strategic Plan for the Ministry of National Education (2010-14), the recent Tenth Development Plan (2014-18) and the Lifelong Learning Strategy Document and Action Plan (2014-18).

Additional documents to review [focus on England, Israel, South Korea and Turkey]

Document Title	Description and Source
Quality of Teaching and Learning in Science	Authored by Costa and Araujo (2018), this documents identifies best practice for teachers: Perspectives from European countries, including England and Turkey
The Teaching Profession in Europe: Practices, Perceptions, and Policies	This is an Eurydice Report, which identifies Practices, Perceptions, and Policies on great teaching and teachers
Teaching Excellence through Professional Learning and Policy Reform: Lessons From Around The World	Authored by Andreas Schleicher (2016), this document points out how to develop professional teachers and linking with a collaborative culture around the world.
Valuing our Teachers and Raising their Status: How Communities Can Help	Authored by Andreas Schleicher (2018), this document pays attention to teachers' pedagogy, beliefs and the impact of communities on teachers' competency
Developing Great Teaching: Lessons from the international reviews into effective professional development	Teacher development Trust (2015) launches a report which focuses on identifying the components of great teaching.
Believers, Seekers And Sceptics: What teachers think about continuing professional development	Welcome Trust (2006) forefronts teachers' perspective on PD based on UK.

Appendix 1: Pilot study interview questions

INTERVIEW QUESTIONS

Researcher's Background Information

I am Emrah Ozyurek from Turkey. I am funded by Turkish government to pursue my postgraduate studies. I studied Chemistry and got two Master's degree, one of which is in physical chemistry in Turkey and other one is STEM education in the UK. I had a 3-year teaching experience as a chemistry teacher in Turkey. The motivation behind conducting this research is to understand the notion of virtuosity in science teaching in other jurisdictions like United Kingdom, Singapore and South Korea.

The purpose of the interview

This interview aims to examine the notion of virtuosity in science teaching, leading towards how an excellence *science teacher* can be described. This interview enables me to glean insight into how teacher experiences virtuosity in teaching practice.

Interviewee's right

The conversation will be recorded and stored on an encrypted device until it has been transcribed by the researcher. No-one else will have access to the recording, and it will be erased once the transcript has been completed. You will have the right to withdraw anytime during the interview. Unless you want to answer any interview questions, you will have a right to move other interview questions.

In this interview interviewee will be asked to answer questions below

1. Why did you choose teaching as a career?

- Could you give an example of something that you do as a teacher that makes teaching as a profession or job?

2. What are the three main personal goals you believe are most important for your work as a teacher?

- Please explain why these are the most important goals for you?

3. What do you think describes a "great teacher"?

- Why do you think this?

4. What personal characteristics does a teacher need if s/he is going to be a great teacher?

- Why do you think this? Could you explain please?

5. Please tell me about something you have done / achieved as a teacher that you are most proud of.

- Would you describe this as being an "great teacher"? Yes / No, explain why

If no, what would have made this an example of being a great teacher?

6. Who/ what inspires you as a teacher?

- Could you explain how does s/he/ it do this?

7. I am interested in the notion of "virtuosity". Please can you name a virtuoso in any field that interests you?

- Why do you think this person is a virtuoso? What qualities does h/she have?

8. Does person who is virtuoso in other fields has similar qualities or characteristics with teacher in educational context?

- If it is, could you explain how these qualities present their selves in the classroom?

9. How do teachers who have those elements of virtuosity help students attaining in human flourishing?

10. Do you think it is possible for a teacher to be a virtuoso? Yes/No

- Why do you think this?

This is the end of interview. Thank you very much to be a part of my study. I am appreciated with it.

Appendix 2: Interview schedule

INTERVIEW SCHEDULE

Interviewer: Interviewee:

Time: Date:

Phase 1: Opening

- Introduce myself
- Brief explanation about the research
- Inform interviewee's right

Phase 2: Asking the Interview questions

- Teaching Experience
- Great teacher
- Development
- Personal goals as a teacher
- Achievements, awards

Phase 3: Closing

Appendix 3: Transcript of interview with Ava in England (pseudonym) [Pilot study]

Me: Could you introduce yourself please?

Ava: I am Ava. I am teaching chemistry biology and physics and doing it quite a long time since 2000.

Me: Why did you choose teaching as a career?

Ava: Ohh that is a good question. My path is a little bit different from other people because my original degree is an Marin biology. I then became a scuba diving instructor. From being a diving instructor teaching people how scuba dive and I also run some Marin biology courses. Then I realised my teaching ability. I really enjoyed it. And then I became a teacher. Yeah I realised that I kept teaching from teaching scuba diving to being a teacher in the classroom.

Me: It is a really different story interesting.

Ava: Yeah it is a bit detailed though.

Me: Could you give an example of something that you do as a teacher that makes teaching as a profession or job?

Ava: Teaching is definitely a profession for me because you have an identity being a teacher so if someone asks you what do you do for a living? You say I am a teacher and it is a lot pride of with that even though majority of people say ohh would not be a teacher. for me teaching is a profession and sense of pride for me.

Me: Why do you think it is a profession rather than a job?

Ava: You know we keep working and keep doing the job hard even though we do not get salary increases. You know if we work in different profession like lawyers or accountancy etc, salary increases considerably. And so why do we keep doing it? ☺ At the moment literally this month I have had a pay increase but basically nothing. Actually a lot of teachers now but my situation is a bit different I work part time and doing a PhD as well. so I do not think I will teach so much longer. My job role will change. Personally unless you within a school you need to take on extra responsibility for Key stage 3 or 4 whatever that would give you extra money.

Me: What are the three main personal goals you believe are most important for your work a teacher?

Ava: Number one is definitely relationship with students. I would say I always well prepare. Basically, I do not take my emotion into a lesson. I do not reveal personal things I am always fair and keep the rules of the school. I think because ultimately it is also for students if I was not well prepared and if I had not good relationship and if I talked about myself all the time then there would be no learning I think.

Me: What do you think describes a “great teacher”?

Ava: It is funny yeah actually those three things that I have just told you I look for another teacher because you know I have trained science teachers and those are my expectations from others teachers. I am not the friend of students. so teachers should be friendly but they are not a friend. As a teacher trainer, I would expect them to prepare lesson well and achieve lesson objectives and reflective on their own practice. Yeah I can add reflection on your practice and I do all the time. but I also believe that there should be work-life balance. If you go extra mile for students and feels hardship and it impacts on your homelife then do not do it but if you feel good while doing something extra for students, then do it. Sor for me, I have been teaching for a long time you know before I have children before marriage, I used to work hard but now I do not have just that time.

Me: What personal characteristics does a teacher need if s/he is going to be a great teacher?

Ava: I think there not one characteristic. being a great teacher requires you do not say that someone is always a great teacher that is a sort of pressure you know I reached the status what is called Advanced Skills Teacher (AST) and basically that was a level of teaching with regard as great teacher like a label and for a while in the UK there were this label and practitioner and there was not great teacher and if you become one then you got a pay increase. So the term great teacher has been around for a while but it was always about the quality of your lessons and then somebody else made decision whether you reached. I think it is too much pressure on UK teachers and government changed so myself I was an AST and reached that level but I am no saying every single lesson that I have thought make me a great teacher. so if I come back to your question. Consistency is important characteristic great teacher is always consistent and reflect on that in practice. you made very good lesson one day and terrible lesson next day but if you are reflect on it, you are always trying to be better. Great teacher is someone who is always trying to improve himself. Subject knowledge is tricky one you know you might have really good subject knowledge but subject knowledge has to be accessible to the students. so there is no point being PhD in astrophysics if you cannot then explain or whatever you try to teach children at their level so what we often try to with trainee they come in very high knowledge not about forget those knowledge but retrain themselves it is just making knowledge accessible to students. and really understanding of curriculum. So there is no point to teaching kids about stuff that in not coming in the exam because it is a waste of time you have teach them what is on the exam. If you are in a private school where students are wonderful then you can go a little bit extra give them some other subject knowledge. but the school that I worked at there is not enough time because you just have to teach them what is in the exam.

Me: Please tell me about something you have done / achieved as a teacher that you are most proud of.

Ava: A school that I worked at 8 or 9 years ago. There were a group of boys who were at risk of being permanently exploited from the school because their behaviours were extremely bad. At that time I was teaching GCSE land-based environmental science. it is very much hands-on practical GCSE. And boys were doing that I basically got funding from academy trust which gave us money we got pigs and boys were in charge of looking at pigs basically. The boys all six of them stayed at school their behaviour improved and actually ended up getting GCSEs and three of them got decent GCSE. For me that was a personal achievement because otherwise these boys would be nothing and would not be succussed. Hopefully they have better quality of life.

Me: Would you describe this as being a "great teacher"? Yes / No, explain why

Ava: Perhaps yes because I went the extra mile with those boys I was preparing to work out at the weekend yeah. At that time I had not thought about it like that but actually what I have done changed the boy's life and it makes me proud and feel a great teacher.

Me: how do you motivate those children who are not interested in science?

Ava: Ohh that is hard. Okay I have four classes year 10 and year 11 who are not all of them but they are difficult classes. they are low ability but consistency, being fair and probably rules and subject knowledge trying to make it why they need to learn about this . You know some topics are easier than others and some topics have no relevant everyday life at all. But if the topic does relevant then it is easier to get engaged students with that topic. You know some of them practical and hands-on work is better and they would be motivated that way so it is huge variety of things that I use. I used the school system as a reward as well. that has a positive effect phone call home building a relationship with their parents it is very important because if the parents get the positive call, that works really.

Me: Who/ what inspires you as a teacher?

Ava: Probably I work with Dr JS and I worked together in teacher training course. He is now 60s. He is so enthusiastic about teaching. so I would say I inspired by him I think.

Me: I am interested in the notion of "virtuosity" in teaching. Please can you name a virtuoso in any field that interests you?

Ava: Could you give an example?

Me: In music for example Mozart is a kind of virtuoso.

Ava: Yeah, I see hmm as an early teacher you know people like David Attenborough and you know not people that I inspire but people who are visual our daily life. Now it is people who work or lead about ohh gush I am terrible it names so I am looking book there is a guy he is not very well known yeah

Ava: Why do you think this person is a virtuoso? What qualities does h/she have?

Ava: hmm I think passion on his subject.

Me: Does person who is virtuoso in other fields has similar qualities or characteristics with teacher in educational context?

Ava: I think age and experience would be the most influential factor because if you are 23 year old and a new teacher you do not have enough life experience so you know those people who you called virtuoso have life experience about what they do so teachers have life experiences influence what they do in front of kids. So for example my teaching style does not influence all students in the class. but some of them they get it and build good relationship with me. When I meet any of them in 10 years-time in the pub, say I love your lessons and remember your lessons but not is everybody.

Me: Do you think ethical and moral values are important in science education context? If it is so, could you explain why?

Ava: They are very important I think it is so important in the UK that we have rules that we have to follow so teachers are trained basically told having a good behaviour like that. So we have very strict guidelines in schools. So there is online training that we have to do every year multiple choice questions and it is all about safe guarding and how so ahh the online training now covers things like how to identify students going through female genital mutilation (FGM). We have a clear guideline about how to deal with some ethical issues so we as a teacher some standard to achieve and whole ethics and moral standards within teacher training are taught. DfE set that for teachers in the UK.

Me: Do you think it is possible for a teacher to be a virtuoso? Yes/No

Ava: Yes I think so because the gentleman that I mentioned earlier Dr JS he does the teacher training of science teacher I see him as a virtuoso teacher because he got experience he is passionate he stands up in front of people who want to be science teachers and he models what the teaching is but he is also learning all the time still learning still improves himself.

Me: When you think overall what is the difference between great teacher and virtuoso teacher?

Ava: I think life experience

Me: How do you think experience teacher impact on students learning outcomes compared to less experience teacher?

Ava: Probably great teacher is going to influence a great number of students than novice or less experience teachers. It is an experience matter you know every single lesson you teach is not the same so the more lesson you teach the more resilient become and the more aware of misconceptions and where students struggle and what students find easy so you can almost predict what the students are going to be able to learn but you cannot do it if you are not enough experience on those subjects. Especially in science because things change year to year so in your very first year of teaching and you learn so much in that year and then when you come to second year you will find you develop and change style and students started to get more those lessons.

Appendix 4: Revised interview questions [Main study]

PROFESSIONAL DEVELOPMENT AND TEACHER EXCELLENCE IN SCIENCE TEACHING

The motivation behind conducting this research is to understand how chemistry teachers' professional identities are shaped and refined through professional development activities based on community of practice approach.

This forms part of my PhD project at Durham University School of Education. The project is investigating in what ways professional development activities impact on chemistry teachers' professional identities for chemistry teaching. Your sincere answers to questions and participation will support how excellence in *chemistry teaching* can be described, and how this develops. Thank you for agreeing to participate in the study.

Emrah Ozyurek
PhD researcher, Durham University

Interview Questions

1. Please tell me who you are, about your teaching experience, your training to be a teacher, and your current teaching position.
2. What professional development experiences have you had that support your work as a teacher?
   - Which of these has had the most significant impact on your practice as a teacher?
   - Please explain why you think this.
   - Which professional development experience has had the least impact on your practice as a teacher?
   - Please explain why you think this.
3. In what ways has the PD enabled you to update your knowledge of science?
4. In what ways has professional development promoted exchange of knowledge expertise between teachers?
5. Please tell me what you have done or achieved as a chemistry teacher about which you are most proud. Why are you most proud of this achievement?
6. What would you say are your professional beliefs about teaching chemistry?
   - Please describe, if you can, how your beliefs have developed and changed through your time working as a teacher.
   - What has prompted your beliefs to change?
7. What personal goals are most important for your work as a teacher?
   - Please explain why these are the most important goals for you?
8. Would you describe yourself as an "great" teacher? Explain why/ why not?
   - If yes, how did you become an excellence teacher?
   - If no, is being an excellence teacher important to you?
   - In what ways participating in professional development supported your development as a teacher?
9. What qualities do you think make a teacher "great"? Please explain.
10. Which is the most significant personal value that you communicate to students? Please explain.

This is the end of interview. Thank you very much for contributing my study. I a very much appreciate it.

Emrah Ozyurek

Appendix 5: Pilot study of focus group interview with prompts

Task I

Which statement do you think the most important? Give me reason. Moreover, if you put in an order from the most important to the least important, how would your order be? Why?

- **Teachers' identity, values and approaches to do with teaching science in general and chemistry in particular should not directly be affected by the policy of a government (that is, the course of action that a government favours and supports)**

- **All teachers should attend professional development to develop their professional knowledge as they move through their career because curriculum change, assessment trend change school resources change etc.**

- **The aim of professional development for teachers should develop and shape their professional knowledge to make students be a responsible citizen and actively participate in society.**

- **Teachers must come together to shape and update their professional knowledge to provide students with better academic outcomes.**

- **Science teachers who teach at high-school science class must have good subject knowledge rather than pedagogic knowledge.**

- **Science teachers who teach high-school should be responsible for providing students with in dept knowledge rather than superficial knowledge.**

- **School science should not be isolated from society. It must focus mainly on making students interested in societal issues in addition to preparing for exams.**

Task II

What do these words mean for you in practice ?

Go the extra mile for students

High-leverage practice

Self-reflection

Personal values

Virtues

Science Identity

Collaboration

Professional knowledge

Beliefs

Appendix 6: Transcript of focus group interview in South Korea [Pilot study]

Teacher 1: Okay, recording, I need to study English. I use English deliberately

Teacher 2: Do you interview in English? (Ask Teacher 1) We will do in Korean☺

Teacher 1: Hahaha

Researcher: Teachers are reading statements.

Teacher 1: hmm this document I think it has been translated well.

Teacher 2: What will we talk about?

Researcher: There are statements here so order them from the most important to the least one

Teacher 1: Yes

Teacher 2: I will just make sure that will I say the most important and the least important?

Researcher: Yes and reason please

Teacher 2: Okay one by one I got it

Teacher 1: I could not caught it how could we order them?

Teacher 2: Just order what you have seen

Teacher 1: I need a white board to write them down

Teacher 3: Just write down on the paper given

Teacher 1: Do I need to write my name here?

Researcher: Yes please

Teacher 1: Okay I need to think in deeply. It looks tough

Teacher 2: It really difficult to order these statements. All of them are really important and true

Teacher 1: There is no right answer in education☺

Researcher: In social sciences there is not one correct answer.
Teacher 2: Yes, yes definitely. Hmm I think this is important but this is more important than this one

Teacher 1: What was ㄱ about?

Teacher 2: It is about government and policy

Teacher 1: we should not be affected by the policy

Teacher 2: Yes

Teacher 1: actually, here in Korea, I have never experienced intervention by government on what I should do or not so that is why when I see something related to government impact on education I automatically put that statement at the end.

Teacher 2: I have done. Do I need to order with letter or number?

Researcher: It does not matter. Just do it as you wish please

Teacher 2: I think all of us have answered the same order for task 1. I will start explaining why I chose that order. I emphasized the importance of responsible citizen when I teach chemistry in class. It is the first one I picked. We cannot think knowledge for just exam. We would rather teach knowledge for how to keep better life and how we make world around us better. That is why I think I should get my students gained about scientific literacy. Therefore, I thought that the most important thing is to become a responsible citizen and actively participate in intellectual activity. After that, I put number 7. It is similar to number 3. We should put emphases on societal issues. I always let my students know what I saw in social media. . That is why students who take my class know that Teacher 2's class is about "class which help people in life" and emphasised that it is not a simple chemistry class, but a class to share and learn life. I could think like that because I learnt lots of things from this PD activity. I think it is important to get together with teachers who share common interest. I thought that 90% of my teaching has been shaped through this PD activity.

What I found the most significant is that teaching deep knowledge is important because if you are aiming at preparing students to exam then they can find information on the Internet. It is easy nowadays. But I think most importantly teaching knowledge for thinking better should be the aim of teaching.

Therefore, it is really so important to meet in this meeting with teachers who have the same beliefs about teaching science. I am the oldest member of this PD course. I do not make appointment on Tuesdays. As if other people go to the church on Sunday, I come here.

Besides, I do not agree that teacher should be better subject knowledge than pedagogic knowledge. You have to make an effort to improve your subject knowledge but more important than those is PCK. Of course, if you have both, then it is perfect but if you ask me to order I would definitely say pedagogical knowledge is important.

Lastly, I rarely follow the government guidance and rather the opposite. So I put it end.

Teacher 3: I think it means that you should not be influenced by government policy.
Teacher 2: I see, in Korea, as a teacher, I am free to teach on my own way. Like government does not say to me you should teach from this material or have to go to those courses for your PD. I can decide which materials I will teach and which course I will take for my PD.

Teacher 3: My answers are almost the same although it is a bit slightly different. The reason why I chose educating for responsible citizen is nearly the same with Teacher 2. Teacher's professional development should aim at raising students who play a role in improving better society and being a part of it through science knowledge. Getting students gained knowledge it does not matter what kind of knowledge it would be but knowledge should support students to decide what they should be able to or not. I also believe that learning science is important to make this world better place to live.

For professional development I think it is important to participate in courses rather than developing yourself alone. As a teacher, not only do I prepare my students for exam, but I also prepare them for society. It requires deep knowledge. In order to deliver knowledge, pedagogic knowledge is more important than subject knowledge.

In some cases like pandemic and typhoon etc, we are also cooperating with government. As a teacher, I am free to do what I want as government does not get involved what we should be able to do. That is why this statement is a bit weird for Korean teachers. We have curriculum to follow but not government to follow.

Teacher 1: I think it is my turn. It is really difficult. Okay. You know this Number 3 is the most important for me. Why did I think like that is that in order to teach science properly, professional development is essential but the aim of PD should be for students' progress. I believe that schooling or school education should guarantee students' happiness. In my personal opinion, individual happiness depends on person's ability or component. That is why I think that happiness to the extent depends on development of society. Society contributes to person and helps individual to develop themselves and become a talented person. Society and individual's happiness go hand in. To become a competent person, scientific reasoning and literacy should be taught to students. if I highlight again, if you gain skills and ability that our society require, then you become happy and contribute to society.

The second point that I would like to mention is that in order to nurture such talents, the subject knowledge taught by teacher should be specific. Superficial knowledge is not fun. According to research when you explain a topic to student if you make the topic related to your life, then students become more motivated to listen to you. That is why even when I solve the problem, I make an effort to make it related to story. Story telling is really important when you teach science.

Next point, that is actually what I have done in the past. I worked as a curriculum developer. It is useless to develop curriculum based on couple of expertise who are not experience in teaching and do not know about how children learn and develop. In order to increase educational effectiveness, teachers who are spending time with their students reflect their opinion to policy makers and policy makers pay attention to teachers as well.

When I move to another point, I believe that individual self-improvement comes first then it makes sense to attend PD activity. If you do not improve yourself, then the learning community does not contribute to your knowledge a lot.

Teachers who cannot do everything I mentioned before, follow the government's instructions. If what I said before work well, then it is not so much important but there are teachers who cannot be as motivated as about teaching. In person, I do not care so much about what government said. Actually, saying every single detail about teaching should not be government's business, teachers should think how to teach better.

Additionally, I think there should be separation necessary, science teacher should be responsible for teaching science not societal issue. If science teacher start to teach societal issues then who will teach science?

Lastly, teacher who want to be excellent or better should pay attention to improve his or her pedagogical knowledge rather than subject matter because students can get subject information from anywhere but pedagogical knowledge is unique for individual. The best teacher is one who leads their students to find the way they study alone kind of coaching. And this is related to pedagogy.

Teacher 4: What I found the most important is students should contribute to society through science. Science is fundamental to figure out problems that we faced nowadays therefore, knowing about science and teaching it are important. Therefore, I prefer to teach in dept knowledge rather than superficial knowledge. students can get superficial knowledge on the Internet but it is important how those superficial knowledge turns into deep knowledge that is why we are as teachers here. Therefore, I found really important to attend PD courses, which I think supports students' result. Because I learn something from here and I apply it to my class and I realised that experiments and up-to-date information that I learned from here motivated my students better.

In terms of knowledge matter, I think teacher should do it simultaneously. Teachers should be competent both SMK and PK.

Researcher: Do government intervene about what you should teach or not? Do you have any restriction?

Teacher 2: Because of the university entrance examination (kind of SAT), we should catch up the curriculum first. We also do mock test for them. but it depends where you teach. In my case, I am teaching a school where majority of students do not take the exam so I am really free what I will teach. In Korea, the exam comes first to be honest. But we do our best to teach extra things.

Researcher: Any other opinion?

Teacher 1: Prerequisite learning is forbidden actually, if I teach physics 1, I cannot teach something from physics 2. What is possible is that I can teach something related to physics 1 like data science, psychology etc.

Researcher: I will get a move on second task. If you do not want to add something.

Teacher 2: What is second task?

Researcher: I have words here so I would like you to express what those words mean in practice for you?

Teacher 1: Do I need to order those words as well? I think we do not have enough time for it.

Teacher 2: You asked which word is the most important or what is the real meaning of those words? So do we need to order first then say what I think right?

Researcher: Yes definitely

Teacher 3: How many words do we need to choose? Is it enough to choose 3 then explain it?

Teacher 1: these words are not for students right?

Researcher: those are for teachers what do you those words mean in practice?

Researcher: For example, science teacher identity what does it mean for you?

Teacher 2: some words are nearly the same meaning?

Teacher 3: Is this self-improvement means how we develop our skills?

Researcher: yeah, how do you develop your teaching etc.

Teacher 4: This word collaboration you mean between teacher?

Observer: Yes

Teacher 2: What is virtuosity?

Researcher: That is, for example virtue pianist someone who is excellent what he or she is doing

Teacher 3: Belief and values look similar to me?

Teacher 2: Okay if I choose 3 of them I will go for beliefs, high-leverage practice and collaboration. My identity as a teacher is to add something about myself to make the class unique for my students. chemistry class is a class which help me how I live and guide me how

I should live. In order to have such an identity, it is important to attend courses and communities. Coming together with other colleagues help me gain different perspectives.

Teacher 1: Belief about teaching. I follow my beliefs that is why now I am a teacher. you know students will be a citizen for our country therefore, I thought how I contribute to society, I found that being a teacher is the best way to contribute society. if I did not have beliefs then I would not have been a teacher. Next, value is important. Actually I would like to express it as a world view though. The view that you have got might shaped how you read world and how you judge situation properly. If I deliver value of education to my students, then I become a successful teacher. third, if I have high leverage practice, it means love about teaching for me.

Teacher 4: for me how to teach comes first and it is related to belief. Based on your beliefs about teaching science, you can teach your students. this requires judgment ability. Second, worries about how to teach better lets me think about how to get high leverage practice so in order to have high leverage practice, attending learning communities is better than doing it alone. The more you meet experience teachers, the more you develop your repertoire.

Teacher 3: Values that shape my life actually decides what kind of person I will be and as a teacher what kind of teacher I will be. Individually I would like to pursue a life which is happy and meaningful. After that I can add my beliefs there and teach better. First of all, I need to enjoy science then I can tell something about science to my students. gaining high leverage practice is important to enhance my skills. Not only I attend this course, I also use my other networks to gain benefits to update myself.

Researcher: thanks very much for attending my interview

Teacher 2: you are welcome. Thanks for your effort to come here.

Appendix 7: Revised focus group interviews with tasks and follow-up questions

PROFESSIONAL DEVELOPMENT AND TEACHER EXCELLENCE IN SCIENCE TEACHING FOCUS GROUP QUESTIONS

The aim of the focus groups is to get the sense of trajectory and experience from teachers who have attended and work collaboratively within same professional development activities.

	Statements	Suggested questions
1.	**Attending professional development**	• Please describe the professional development that you have experienced in the last couple of years. • Do you consider professional development contribute to great teaching? If so, how? • Why is professional development important/not important in science teaching?
2.	**Raising responsible citizens**	• Why should be science taught? • Why does participation in post-16 science matter? • What is the motivation behind teaching science?
3.	**Government intervention on teachers' professional development**	• Could you give an example of something as you think of the policy of the government on PD courses, which has an impact on teaching? • Do you think do PD courses underpinned by government help improve your professional knowledge? • Has the government made changes to improve the quality of PD in the last couple of years?
4.	**Collaboration for better academic outcomes**	• Do you consider collaboration between teachers result in better academic outcomes for students? • Why collaboration is important/not important for students' academic achievement? • Have your views about the importance of collaboration changed after you have started to teach your subject? • Do you have any examples of collaboration, which ends up providing students with better understanding of a subject that you taught?

5.	**Teachers' professional knowledge**	• How do you update your knowledge of a subject in light of recent advances in the field? • How would you describe the professional knowledge of teacher? • Has this changed since you started to teach? If so, how? • How does your professional knowledge impact on students' learning? • What factors influence how professional knowledge is gained and delivered?
6.	**Teacher's beliefs on providing knowledge**	• Do you have an "policy vs personal value conflict" while teaching science in the classroom? • Has your belief about teaching science changed since you become a teacher? • Have your priorities for teaching science changed during your carrier? • Could you tell me how a PD course that you have recently attended made changes your beliefs about teaching?
7.	**Teachers' responsibility/role**	• What does it mean to be a teacher? • How do you describe your responsibility/role as a science teacher? • Has this changed during your career? • What should a science teacher be responsible for? • Why is important/not important being a role model for students?

PROFESSIONAL DEVELOPMENT AND TEACHER EXCELLENCE IN SCIENCE TEACHING

The motivation behind conducting this research is to understand how chemistry teachers' professional identities are shaped and refined through professional development activities based on community of practice approach.

This forms part of my PhD project at Durham University School of Education. The project is investigating in what ways professional development activities impact on chemistry teachers' professional identities for chemistry teaching. Your sincere answers to questions and participation will support how excellence in *chemistry teaching* can be described, and how this develops. Thank you for agreeing to participate in the study.

Emrah Ozyurek
PhD researcher, Durham University

Task I

1. **Please order statements from the most and the least important.**

2. **Explain why you have chosen this order.**

STATEMENTS

1. **Attending professional development**

All teachers should attend professional development to develop their professional knowledge as they move through their careers.

2. **Raising responsible citizens**

Professional development should develop and shape teachers' professional knowledge to make students be responsible citizens and participate actively in society.

3. **Government intervention on teachers' professional development**

Teachers' identities, values and approaches to do with teaching science should not be affected directly by government policy.

4. **Collaboration for better academic outcomes**

Teachers must collaborate to shape and update their professional knowledge to provide students with better academic outcomes.

5. **Teachers' knowledge**

It is more important for science teachers teaching high-school science classes to have good subject knowledge rather than pedagogic knowledge.

6. **Teacher's beliefs on providing knowledge**

Science teachers teaching high-school should provide students with in depth knowledge rather than superficial knowledge.

7. **Teachers' responsibility/role**

School science should not be isolated from society. It should focus on developing students' interests in societal issues in addition to preparing for exams. Therefore, teachers bridge school and society.

Task II

1. **Based on your teaching experiences explain 6 words from those provided that impact on your teaching in practice.**

2. **Please order the words from most to least important.**

WORDS

1. **<u>Go the extra mile for students</u>**

2. **<u>Self-reflection</u>**

3. **<u>Personal values</u>**

4. **<u>Collaboration</u>**

5. **<u>Professional knowledge</u>**

6. **<u>Beliefs</u>**

Appendix 8: Confirmation of ethics approval

Ethical Approval: EDU-2018-11-15T21:45:26-pzxx25

Ethics <no-reply@sharepointonline.com>
Wed 19/12/2018 16:57
To: OZYUREK, EMRAH <emrahozyurek@durham.ac.uk>
Cc: ED-ETHICS E.D <ed.ethics@durham.ac.uk>;KIND, VANESSA <vanessa.kind@durham.ac.uk>

Please do not reply to this email.

Dear Emrah,

The following project has received ethical approval:

Project Title: *IMAGES OF VIRTUOSITY IN TEACHING AND HOW THESE REFLECT ON SCIENCE EDUCATION*
;
Start Date: *02 January 2019*;
End Date: *14 December 2019;*
Reference: *EDU-2018-11-15T21:45:26-pzxx25*
Date of ethical approval: *19 December 2018*.

Dear Emrah,

Your ethics aplication has been approved. The reviewer made some comments/observations about your proposal - see below. Please discuss the reviewer's recommendations with your supervisor. NB. As your ethics application is in place, you do need to submit your response to the reviewer's comments:

The applicant OZYUREK, EMRAH's research proposal and description provided in the form of ethics show commitment to follow the guidelines of ethics in education research (participants' rights and anonymity of individuals involved in research). However, the research design is not clear (comparison groups) and there is over reliance on methods (interviews and observations). There is no indication of population of interest and how sampling of teachers (participants for research) will be conducted. Why 22 teachers would be selected? And how would they be selected? These are important research issues and can have implications on the research process and findings.

Reviewer's decision: Approved

Appendix 9: Teacher participant briefing

Teacher Participant Briefing

PROFESSIONAL DEVELOPMENT AND TEACHER EXCELLENCE IN SCIENCE TEACHING

Emrah Ozyurek, PhD Researcher,
School of Education Durham University, UK

Background Information

My PhD study is funded by Turkish government. I studied Chemistry originally, then obtained two Master's degrees, one in physical chemistry from Marmara University, Turkey and the second in STEM education from Brunel University, UK. I taught chemistry for three years. I am currently pursuing my PhD study under the supervision of Professor Vanessa Kind and Professor Doug Newton at Durham University in the UK. The motivation behind conducting this research is to understand how chemistry teachers' professional identities are shaped and refined through community-based PDs and lesson studies, both of which are informal professional development activities based on community of practice approach. I am investigating how teachers enhance their ability to make educationally appropriate judgements, and how their practical wisdom and virtues such as intellectual, performance, moral and civic impact on their decision-making.

The purpose of the interview

This interview aims to examine in what ways professional learning communities and lesson studies impact on chemistry teachers' professional identities for chemistry teaching. The interview intends to investigate how excellence in *chemistry teaching* can be described, and how this develops. In particular, this interview seeks insights into how teachers benefit from professional development to improve their teaching practice.

Interviewee's rights

The conversation will be recorded and stored on an encrypted device. No one else will have access to the recording. The recording will be erased once transcription has been completed.. The interview will be used solely for research purposes. You will not be identified by name in any publication arising from the study. You have the right to withdraw at anytime during the interview

Appendix 10: Example of teacher consent form

School of Education, Durham University, Leazes Road, Durham, DH1 1TA ,United Kingdom

Dear
Thank you for agreeing to be part of the PhD study into Professional Development and Teacher Excellence in Science Teaching. The study is led by Emrah Ozyurek, a postgraduate researcher in Durham University's School of Education UK. The project is funded by a Turkish Government studentship. It would be very helpful if you would participate in a group interview. There are two tasks. You are free to answer as many or as few questions as appropriate. It would be very useful if you would respond to all of them. Alternatively, you can complete the tasks electronically in writing. Once complete , please email it to **emrah.ozyurek@durham.ac.uk**

This is to confirm that you will be identified by name in my PhD thesis or in any paper published from the thesis in the future. Data are collected under strict ethical and data protection guidelines. Data are stored in encrypted files, never shared with third parties, and used only for the purposes of this project. The study has ethical clearance from Durham University's School of Education Research Ethics Committee and is conducted in accordance with British Educational Research Association (2011) guidelines. Completion of the form or interview is on a voluntary basis and you may withdraw at any time.

Professional development and the notion of excellence in teaching science is a long-standing commitment in science education. Thank you for your help in helping me to investigate this.
If you have any questions, please contact me.
Thank you again for your support.

Emrah Ozyurek, PhD Researcher

School of Education, Durham University, Leazes Road, Durham, DH1 1TA ,United Kingdom

Re: Professional Development and Teacher Excellence in Science Teaching PhD Project, Emrah Ozyurek

I ________________________________ agree to participate in the above project.

I give permission for my responses to be held securely for the purposes of this project only.

I have been told of my rights as a volunteer participant and understand that I may withdraw at any time, and answer as few or as many questions as I wish.

Signature: ______________________

Name: ________________________

Date: ____________________________

Appendix 11: Teachers' Pseudonyms

Country	England	
Pseudonyms	So-yeon	Su-mi
	Seon-mi	Se-hoon
	Sung-sook	Seo-jun
	Sang-cheol	Sang-woo
	Si-eun	So-ra
Country	**England**	
Pseudonyms	Emma	Erik
	Elizabeth	Eva
	Ethan	Elena
	Emily	Emilee
	Eliot	Elisa
Country	**Israel**	
Pseudonyms	Isaac	Inbar
	Ilana	Ioane
	Ivana	Irene
	Irit	Isabel
	Idit	Ivanka
Country	**Turkey**	
Pseudonyms	Turgut	Tuba
	Tamer	Temel
	Türkan	Tanyeli
	Tolga	Tezcan
	Tülin	Tugçe

Appendix 12: PD content in South Korea

Date (2019)	Title	Description
09.17	How to make Beeswax	Zero waste refers to a lifestyle that aims for a waste-free life. After a YouTube video of inadvertently discarded plastic garbage floating in the sea without decaying an stuck in the nose of a sea turtle, many people began to promote plastic-free, zero-waste life. Beeswax wrap is one of the eco-friendly materials that replace the existing plastic wrap. Beeswax is extracted from the lower part of the abdomen of worker bees. It is a yellow natural wax. The scraped sugar is sieved by enzyme reaction. This is a substance produced by worker bees to make hive and lay eggs. The main component is hydrocarbons and cetyl palmitate. The melting point is about 62 Celsius.
09.24	Observing the daphnia heartbeat	Daphnia is a zooplankton that plays an important role in the aquatic ecosystem and its transparent body makes it easy to observe its internal structure through a microscope. In particular, the translucent heart is beating on the back of the daphnia. Adrenaline and acetylcholine affect the heartbeat of the daphnia just like in humans. By directly treating daphnia with adrenaline and acetylcholine, students can learn how the two substance regulate the heartbeat in our body.
10.01	Covalent card game	Lewis electron dots and structural formulas are the basics when expressing molecules in chemistry, but they are also unfamiliar and difficult for students to learn for the first time. Using a covalent bond card game, students can naturally practice Lewis electronic dot and structural formulas.
10.15	Rock Tree	A rock is an inorganic solid that is mixed with various kinds of minerals. Rocks are largely divided into igneous rocks, metamorphic rocks and sedimentary rocks depending on the conditions under which they are formed
10.22	Making flexible electrodes using liquid monsters	The liquid monster is a material that students often use as a science booth operation during club activity. You can easily find slime. You also came across various ways of playing with liquid monsters on YouTube. In this way, I would like to

		look into various ways of using polymers by making electrodes with slime, one of the most familiar polymers, to compose a battery. In particular, as various fields using conductive polymers are emerging with the recent advent of flexible, foldable displays, and ESS. It is expected that an understanding of the latest information and electronic materials will be improved.
10.29	What to eat in the future?	It is estimated that the world population will reach 9-10 billion by 2050. Such a large population will need almost twice as much food as it does today to survive. Addressing future food and nutrition challenges requires findings new ways to increase food while increasing efficiency and reducing food waste. Let's take a look at edible insects.

Appendix 13: PD content in Israel

Date (2020)	Title	Description
15.01	Diagnostic test about misconceptions in chemistry classroom	Ivana from the Weizmann Institute of Science gave a presentation about common misconception about oxidation. She also handed in some worksheets and wanted teachers to fill in. Teachers separated different groups and each group tried to solve problems related to oxidation. Example $Cl_{2(g)}$ + $2Br^-_{(aq)}$ ----- $Br_{2(l)}$ + $2Cl^-_{(aq)}$ 1. Determine for each of the statements whether it is true or false 2. Correct the statements that are not correct a) Electrons move from Cl^- to Br^- T( ) F ( ) b) Electrons move from $Cl_{2(g)}$ to $Br^-_{(aq)}$ T( ) F ( ) c) The oxidizer in the reaction is Cl^- because it gained electrons. T( ) F ( ) d) Br_2 is the reactant in the reaction because the bromine atoms have increased in oxidation state from -1 to 0. T( ) F ( )
20.01	Project-based learning in physic classroom	Project-based learning is an approach that gives insight students into how to solve the problems that they come across in daily life by applying interdisciplinary approach. Teachers guide students to find sources, write a report and how to present the work. The project-based learning comprises six stages. They are, reviewing sources and decide the topic; writing a proposal, application of project; preparing for the presentation; presentation and assessment. Example of a project conducted in the school. Title of project: Heat and Insulation Invitation: Our high school will be rebuilt next year. Would you like to contribute to the construction of our high school where you will be educated?

		Aim of the project: To minimize heat loss, we must provide thermal insulation on the floor, roof, heating installation, walls and windows of the building. Group working: Now you are divided into 5 in the class. Research the insultation materials. Decide which materials provide better thermal insultation
22.01	A customised kit for the diagnostic task	Given the molecular substance glucose whose molecular structure formula is C6H12O6. Which of the following sentence describes what happens to glucose molecules when dissolved in water? • They break up into ions, the ions are surrounded by water molecules • They are separated from each other, the molecules are surrounded by water molecules • They break into atoms, the atoms are surrounded by water molecules.

Appendix 14: Classroom observation protocol

Oregon Teacher Observation Protocol (OTOP) (Based on a good PCK model proposed by Kind and Chan, 2019)

L. Flick, P. Morrell, C. Wainwright – 2004 http://fg.ed.pacificu.edu/wainwright/index.html

Investigating how teachers enhance their ability to make educationally appropriate judgements, and how their practical wisdom and virtues such as intellectual, performance, moral and civic impact on their decision-making are important to build up teachers' professional identity. Therefore, this classroom observation protocol has been designed to observe two types of teachers' professional knowledge and how those knowledge impact on knowledge of students. Types of knowledge that will be observed in this study is Pedagogical Knowledge (PK), which consists of four sub-components; knowledge of instructional strategies, classroom management, organisation of resources and materials, and knowledge of assessment and curriculum; and Content Knowledge (CK), which comprises facts and concepts.

BACKGROUND INFORMATION		
OBSERVER	Emrah Ozyurek	
DATE OF OBSERVATION		
LENGTH OF OBSERVATION (Minutes)		
Was the teacher informed about this observation prior to the visit?	Yes O	No O
OBSERVEE		
NAME		
GENDER		
YEARS OF EXPERIENCE		
CLASSROOM DEMOGRAPHICS		
What is the total number of students in the classroom?		
Was a teaching assistant in the class?	Yes O	No O
Teaching Year		
Class Context		
Subject Observed/Descriptive Course Title		
Scheduled length of class (Minutes)		

This instrument is to be completed following observation of classroom instruction. Prior to instruction, the observer will review planning for the lesson with the instructor. During the lesson, the observer will write an anecdotal narrative describing the lesson and then complete this instrument. Each of the ten items should be rated 'globally'; the descriptors are **possible indicators**, not a required 'check-off' list.

In this section, you are asked to rate each of a number of key indicators as descriptive of the lesson in five different categories, **from 1 (not at all) to 5 (to a great extent).** Note that any one lesson may not provide evidence for every single indicator; use DK, "Don't Know," when there is not enough evidence for you to make a judgment. Use N/A, "Not Applicable," when you consider the indicator inappropriate given the purpose and context of the lesson.

Type of instruction

L: lecture/presentation
PM: problem modelling
LWD: lecture with discussion
D: demonstration
CD: class discussion
WW: writing work (if in groups, add SGD)
RSW: reading seat work (if in groups, add SGD)
HOA: hands-on activity/materials
SP: student presentation (formal

SGD: small group discussion (pairs count)
CL: cooperative learning (roles)
LC: learning centre/station
TIS: teacher/faculty member interacting w/ student
UT: utilizing digital educational media and/o technology
A: assessment: Please describe.
OOC: out-of-class experience
I: interruption
OTH: other: Please describe.

1. This lesson sought to stimulate students' interest and curiosity in chemistry

	1	2	3	4	5	DK	N/A
Teacher							
Presented open-ended questions							
Encouraged discussion of alternative explanations							
Presented inquiry opportunities for students							
Provided alternative learning strategies							
Students							
Discussed problem-solving strategies							
Posed questions and relevant means for investigating							
Shared ideas about investigations							

Time in minutes

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												
Students												

2. Teacher encouraged students to develop chemical understanding

	1	2	3	4	5	DK	N/A
Teacher							
Encouraged students to explain their understanding of concepts							

Encouraged students to explain in own words both what and how they learned							
Routinely asked for student input and questions							
Students							
Discussed what they understood from the class and how they learned it							
Identified anything unclear to them							
Reflected on and evaluated their own progress toward understanding							

Time in minutes

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												
Students												

3. In this class, teacher sought to organise collaborative learning strategy among students to build up dialogical classroom.

	YES	NO
Teacher		
Organized students for group work		
Interacted with small groups		
Provided clear outcomes for group		
Students		
Worked collaboratively or cooperatively to accomplish work relevant to task		
Exchanged ideas related to lesson with peers and teacher		

Time in minutes

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												
Students												

4. This lesson promoted growth-mindset, which generates authentic questions related to the topic

	1	2	3	4	5	DK	N/A
Teacher							
Asked higher level questions							
Encouraged students to extend concepts and skills							

Related integral ideas to broader concepts							
Students							
Asked and answered higher level questions							
Related subordinate ideas to broader concept							

Time in minutes

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												
Students												

5. Teacher's assessment and curriculum knowledge has been observed

	1	2	3	4	5	DK	N/A
Teacher							
Pre-assessed students for their thinking and knowledge							
Helped students confront and/or build on their ideas							
Refocused lesson based on student ideas to meet needs							
Students							
Expressed ideas even when incorrect or different from the ideas of other students							
Responded to the ideas of other students							

Time in minutes

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												
Students												

6. Teacher's content knowledge presentation has been observed

	1	2	3	4	5	DK	N/A
Teacher							
Presented information that was accurate and appropriate to student cognitive level							
Selected strategies that made content understandable to students							
Was able to field student questions in a way that encouraged more questions							
Recognized students' ideas even when vaguely articulated							
Students							

Responded to instruction with ideas relevant to target content							
Appeared to be engaged with lesson content							

7. The teacher/instructor utilised different instructional strategies

	1	2	3	4	5	DK	N/A
Teacher							
Used multiple methods, strategies and teaching styles to explain a concept							
Used various materials to foster student understanding (models, drawings, graphs, concrete materials, manipulatives, etc.)							

Time in minutes

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												

8. Curriculum knowledge has been integrated with previous topics and content (spiral curriculum point of view)

	1	2	3	4	5	DK	N/A
Teacher							
Integrated content with other curricular areas							
Applied content to real-world situations							
Students							
Made connections with other content areas							
Made connections between content and personal life							

9. Teacher's practical wisdom ability along with the implementation of big ideas has been observed

	1	2	3	4	5	DK	N/A
Teacher							
Encouraged input and challenged students' ideas							
Was non-judgmental of student opinions							
Solicited alternative explanations							
Students							
Provided evidence-based arguments							
Listened critically to others' explanations							
Discussed/Challenged others' explanations							

Time in minutes

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												
Students												

10. This lesson motivated students to grasp morality behind chemistry.

	YES	NO
Got students to gain the ethical sensitivity and ethical judgement		
Helped students understand their ties to society and their responsibilities within it		
Exhibited pedagogical phronesis in his/her dealings with students		

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Instruction												
Teacher												

For the following questions, select the response that best describes your overall assessment of the *likely* of this lesson in each of the following areas, from 1 (no impact) to 5 (great impact).

	Not Observed	1	2	3	4	5
Students' understanding of chemistry as a dynamic body of knowledge generated and enriched by investigation						
Students' understanding of important chemistry concepts						
Students' capacity to carry out their own inquiries						

Appendix 15: Professional development activity observation protocol

Oregon Teacher Observation Protocol (OTOP) adopted to Professional Development activity based on Kind and Chan's (2019) amalgam of PCK

L. Flick, P. Morrell, C. Wainwright – 2004 http://fg.ed.pacificu.edu/wainwright/index.html

Teachers' professional identity and knowledge develop over time. Involving in a PD course might be useful to improve teachers' decision making and judgement abilities by collaborating with more knowledgeable and experienced others. This observation gives me insight in relation to how teachers' professional identities are shaped and refined through Professional Development course. Therefore, my observation focuses on five elements (knowledge of instructional strategies, classroom management, organisation of resources and materials, and knowledge of assessment and curriculum and content knowledge) and how those elements are related to knowledge of students.

BACKGROUND INFORMATION			
OBSERVER	Emrah Ozyurek		
DATE OF OBSERVATION			
LENGTH OF OBSERVATION			
LENGHTH OF ACTIVITY (WEEK)			
PROVIDER OF TRANING	GOVERNMENT O	LOCAL AUTHORITY O	PRIVATE ORGANISATION O
TYPE OF ACTIVITY	FORMAL O	INFORMAL O	
Was the director of the PD informed about this observation prior to the visit?	Yes O	No O	

TRAINING DEMOGRAPHICS			
How many teachers are on the PD course?			
The number of teachers involved in the PD course	Male:		Female:
Years of teaching experience	0-5 years:		6-10 years:
			Over 10 years:
Subject speciality of teachers	Physics:	Biology:	Chemistry:
Teaching Year	Year 10:	Year 11:	Year 12:

This instrument is to be completed following observation of professional development activity instruction. During the activity, the observer will write an anecdotal narrative describing the activity and then complete this instrument. Each of the ten items should be rated 'globally'; the descriptors are **possible indicators**, not a required 'check-off' list.

Ratings of Key Indicators

In this section, you are asked to rate each of a number of key indicators as descriptive of the professional development activity in five different categories, from 1 (not at all) to 5 (to a great extent). Note that any one activity may not provide evidence for every single indicator; use DK, "Don't Know," when there is not enough evidence for you to make a judgment. Use N/A, "Not Applicable," when you consider the indicator inappropriate given the purpose and context of the activity.

1. This activity focused on developing teaching strategies associated with underpinning classroom context

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

2. Teachers were provided with active learning opportunities related to a cognitive point of teaching chemistry

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

3. This session of PD course introduced new instructional strategies to do with meaningful connections between skills and ideas, and real-life situations

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

4. This session of PD course provided teachers with the organization of resources and materials, which aimed at students' cognitive development

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

5. This activity helped exchange information and expertise among teachers and others, e.g., academics, industrialists to realise students' preconceptions and misconceptions

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

6. This activity promoted opportunities to update teachers' knowledge delivery of chemistry in light of recent advances through collaboration and job-embedded context.

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

7. Teachers reflected and practiced variety of instructional strategies to represent concepts

1	2	3	4	5	DK	N/A

O	O	O	O	O	O	O

8. Teachers were engaged in teaching tasks based on what students need related to societal issues

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

9. Teachers raised awareness regarding pedagogical reasoning along with the implementation of big ideas

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

10. This activity enabled teachers to question the importance of moral and civic purpose of teaching chemistry.

1	2	3	4	5	DK	N/A
O	O	O	O	O	O	O

Appendix 16: Handout sample from South Korea

밀랍 랩(Beeswax) 만들기

25기 김세진(여의도고등학교)

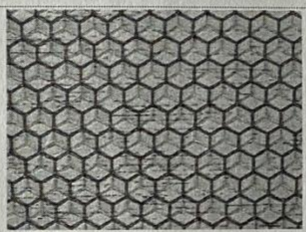
Ⅰ. 들어가기

제로 웨이스트(zero waste)는 쓰레기 없는 삶을 지향하는 생활방식을 의미한다. 무심코 버린 플라스틱 쓰레기가 썩지도 않고 바다에 떠다니다가, 바다 거북이 코에 꽂혀버린 유튜브 영상을 계기로 많은 사람들이 플라스틱 프리, 제로웨이스트 삶을 알리기 시작했다. 밀랍 랩도 기존의 비닐 랩을 대체하는 친환경 소재 중의 하나이다.

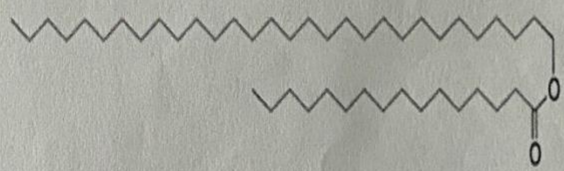
TES-2019

무엇을 알아야 할까?

☐ **밀랍(Beeswax)**



■ 밀랍은 일벌의 배 아래쪽에서 분비하는 노란색 천연 왁스이다. 꽃으로 긁어모은 당을 효소 작용에 의해 체내에서 생성하는 물질로 일벌은 이것으로 꿀을 모으고, 알을 낳아두며, 벌집을 만든다.



■ 주성분은 고분자 탄화수소와 cetyl palmitate ($C_{15}H_{31}COOC_{30}H_{61}$)이다. 녹는점은 62℃ 정도이다.

■ 밀랍을 녹인 후 여과기로 걸러 불순물을 없앤 다음 가공하여 접착제, 껌, 화장품, 광택제(왁스), 양초 등을 만드는데 사용한다.

Ⅱ. 탐구활동 : 밀랍 랩 만들기

TES-2019

이 활동을 하면?

- 주변에서 버려지는 천과 밀랍을 활용하여 비닐 랩을 대체할 수 있다.
- 천연 재료의 구조와 성질을 알고 이를 활용할 수 있는 방안을 탐구할 수 있다.

TES-2019

무엇이 필요할까?

- 면 소재의 천 조각, 밀랍, 종이호일, 다리미, 수건

Appendix 17: Handout sample from Israel

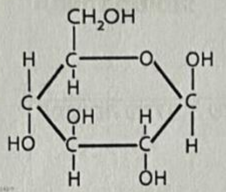
THE TRUMP FOUNDATION
קרן טראמפ

מכון ויצמן למדע
המחלקה להוראת המדעים

ערכה מותאמת אישית למשימה הדיאגנוסטית

מבנה וקישור – תמיסה מימית של חומר מולקולרי

המשימה



1. נתון החומר המולקולרי גלוקוז, $C_6H_{12}O_{6(s)}$ שנוסחת המבנה של המולקולות שלו היא:
איזה מהמשפטים הבאים מתאר מה קורה למולקולות הגלוקוז בעת המסה במים?

א. הן מתפרקות ליונים, היונים מוקפים במולקולות מים.

ב. הן נפרדות זו מזו, המולקולות מוקפות במולקולות מים.

ג. הן מתפרקות לאטומים, האטומים מוקפים במולקולות מים .

2. כאשר ממיסים אתנול, $C_2H_5OH_{(l)}$ במים, החומר נפרד ל:

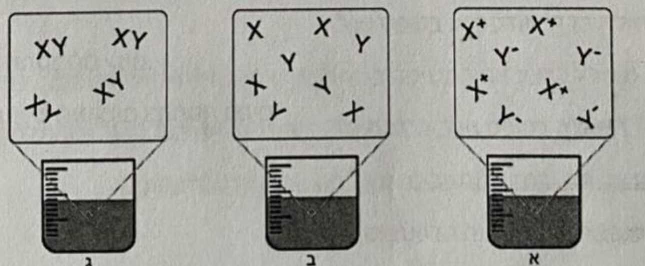
א. אטומי H , אטומי O , אטומי C

ב. מולקולות C_2H_5OH

ג. יוני C^{4+}, O^{2-}, H^+

3. הכינו מהחומר המולקולרי $XY_{(l)}$ תמיסה מימית.

א. איזה מבין המודלים הבאים מייצג את החומר המומס ברמת המיקרו?
הערה: מולקולות המים לא מיוצגות במודל.



ב. נסח את תהליך ההמסה במים של החומר המולקולרי $XY_{(l)}$.

4. ציין ב- √ כיצד התמודדת עם המשימה:

	5	4	3	2	1	
היה לי קל						היה לי קשה

עבודה נעימה!

Appendix 18: Example of translation from Korean and Turkish to English

Ben: Suan X hocamla mulakatimi yapmak uzere XXXdeyim bulunmaktayim. Hocam kendinizi kisaca tanitabilir misniniz? Nasil ogretmen oldugunuzu, ogretmen olmak icin ne gibi egitimler aldiginizi, ogretmenlik deneyiminizi ve suan okulda ne pozisyonda gorev yaptiginizi benimle paylasir misniz? X: Ben 1987 Selcuk universitesi Egitim fakultesi Kimya bolumunden mezun oldum. Agri Lisesinde goreve basladim. Ogretmen olma istegim lise yillarinda kendi ogretmenlerime hayranlikla bakiyodum onlari ornek aliyodum. Ailem her nekdar degisik meslekleri onersede ogretmenligi kendi istegimle sectim. Ogretmenlik hayatim boyunca cesitli hizmet ici egitim kurslarina katildim. Egitm alaninda, ders alininda, yonetim alaninda ve bilgisayar alaninda cok cesitli kurslar aldim. Cesitli okullarda, mudur yardimciligi ve mudur gorevlerinde bulundum. Ancak kendimi sinifta daha mutlu hissesttigim icin yillardirda kimya ogretmenligi gorevini surdurdum. Simdi `Osman nuri hemoglu Anadolu lisesinde uzman ogretmen olarak calimaktayim. Ben: Peki hocam ogretmnelik kariyeriniz boyunca ogretmenlik kariyerinizi destekleyen ogretme yeteneklerinizi gelistiren her hangi bir profesyonel gelism programi veya hizmet ici egitim kursuna katildiniz mi? X: Cok fazla egitim kursuna katildim ogretmen oldugumun ilk bes yilinda her yaz farli bir hizmet ici egitim kursuna katildim. Bu kimya dersi alinda alan bazli, laboratuar araclarinin kullanimi kursnuna katildim. Bu kurs sayesinde gittigim okullarda kimya laboraturalarinin duzenlenmesinde gayet buyuk katkilari olmustur. Yonetim alaninda okul mudur ve yardimciligi konusunda kurslara katildim. Bilgisayar kurslarina katildim. Kimya Alani disinda sivil savunma gibi cesitli alanlarda kurslara katildim. Uzman ogretmenlik sinavina katildim. Yaklasik 10-15 sendir uzman ogretmen olarak.
Me: I am at Hekimoglu Anatolian high school to do interview with Expert Teacher X. First of all, please tell me who you are, about your teaching experience, and your training to be a teacher and your current teaching position. **X:** I graduated from the Faculty of Education, chemistry teaching department at Selcuk University, Konya in 1987. I was appointed to Agri and started working at Agri High School. The motivation behind why I want to be a teacher dates back my high school years. I got inspired by my teachers then I decided to be a teacher. However, my family would like me to choose different professionals. I attended lots of in-service training activities throughout my career like subject-specific, management, technology. I worked as a deputy manager and manager at different schools. However what I feel the most comfortable places is classroom therefore, I have chosen to teaching path and taught chemistry for a long time rather than administrative works. I am currently working as an expert teacher at Hekimoglu Anatolian High school, which is a selected-school. **Me:** What professional development activities and experiences have you had to support your work as a teacher.

X: I have attended lots of professional development courses each summer break especially in first 5 years of my teaching career. I had subject specific courses, I had a course called "how to use laboratory equipment", which helped me a lot to design a chemistry lab in each school that I have been to. I have also attend course in relation to administration. I had courses related to how to use smart board in the classroom and some other courses how to use technological tools in education. Apart from courses, which are related to subject-based, I also had out-of-field courses like civil defence and first-aid. I took an exam to be an expert teacher 15 years ago and now I have been titled as an expert teacher for the past 15 years.
나: 과학 교육에 대한 전문적인 신념은 무엇이라고 말 하시겠습니까?   **화영 선생님:** 과학적 소양을 (attitude or approach) 갖게 하는 것이 가장 큰 목표이다. 아마도 제일 큰 기본적인 목표 같은데. 저는 그걸 애들한테 이렇게 표현해요. 화학 수업이 concept 이 하는 목표가 인생이 도움이 되는 수업이다"라고 정했어요 몇년전부터. 인생에 도움이 된다는 거가 여러 종류의 있던 부분이 있을 수 있는데 그냥 과학만을 얘기하는 거 아니거든요 거기에서 포함은 되죠. 이제 과학적인 뭐 issue 가 또 올랐을 때 그거를 그냥 기계적으로 읽어 싸움 같은 소리 안하고 그런 사람이 되지 않고 issue 에 대한 어떻게 하면 데이터를 제대로 검색할 수 있고 크로스 체킹할 수 있는지도 생각해 보고 가짜 뉴스인지 아닌지 반편해 보기도 하고 단위가 (unit 라돈이 얼마나 많은 unit 이 들어가나) 중요하다는 얘기도하고. 라돈 침대라든지 (침대에 라돈이라는 물질 들어가서 사람의 몸에 harmful 한데도 기업이 그 침대를 판매했어요) 생리대 발암 물질 (period disposal pad 파는 기업이 그걸 안 좋은 chemical ingredient 로 만들어서 여자들이 생리 pad 때문에 암에 걸릴 수 있어요.) 이런 사건이 종종 일어나거든요. 그래서 그럴 때 그 단위가 얼마나 과학적으로 의미가 있는 지 보람 얘기도 되게 간절 좀 하는 표현이에요. 애들이 뭔가를 봤을 때 그냥 그걸 보려는 시도를 하게 만드는 것이 중요하지만 (보려는 시도, 확인하다, 해 보다, 직접 알아 보다) 예를 들어 남들 앞에서 말이 훌륭이라든가 완전 100% 모둠 (group) 활동으로 진행하는데 모둠원 (group member) 중에 마음에 안 드는 애들이 있잖아요 근데 그 아이들과 어떡해 하면 대화를 나누고 아니면. 제가 이제 수업 중에 중간 중간에 글 쓰기도 시키거든요. 글찌기 짧은 글찌기 같은 것도. 그런것 들도 아이들한테 글 쓰는 거 되게 중요한 능력이니까 그런거라근가 아니면 멋있는 그림이나 멋있는 자연의 사진 풍경 예술 자품 노래 이런 것들 되게 많이 소개를 하려고 노력해요. 이 얘기와 아무 관계가 없지만 제가 장년에

제일 좋아했던 영화 "A star is born" lady gaga Bradley Cooper 주연했던 academy 주제 암튼 그런 영화이거든요. 난 그 영화를 굉장히 좋았거든요. 애들한테 그거 소개하고 쉬는 시간에 음악 틀어놓고 애들한테 혹시 시간이 있으면 한번 보렴 이제 삶을 편리하게 만들어 주는 건 과학 기술인데 인생이 풍부하게 (rich, fruitful) 만드는 거 인문 예술이다. 좋은 그림을 보고 좋은 풍경 보고 좋은 노래를 들은 건 굉장히 사람을 행복하는 방법이다. 그런 것들도 많이 소개하는 편이에요. 그렇더니 저는 보람을 느껴요. 애들이 수업을 통해서 배우는 게 과학 지식 배우는 거 아마도 학원 강사들이 더 잘 가르칠 수 있어요 그 사람들이 (학원 강사들) 그냥 맨날 그거만 하니깐 수능 잘 보고 만들어 주는 그 사람들 맨날 그것만하잖아요. 수능을 잘 보게 만들어 주는 것이 그 사람들의 최대 목표니까요. 저는 그런 사람 아니거든요. 저 같은 사람을 통해서 아이들이 삶에 어떤 태도나 어떤 즐거움 어떤 그런 것들이 느낄 수 있던 바래요. 저는 여행 갔다 왔을 때도 그 곳 사진이나 자연 많이 보여주거든요. 저는 꽃 중에 수국 좋아해요 그래서 부산이나 주제 가서 꽃 사진 찍어 보여주고. 그래서 애들한테 수국을 보러 여행 갔다 말해요. 나중에 너의들도 좋아하는 걸 생기면 그걸 하기 위해 하는 삶을 사라라 그러려면 뭐가 필요할까? 그럼 애들 지금 직업이 뭐 이런걸 하겠죠. 그렇게 하기 위해서 그렇게 살았으면 좋겠다고 생각해요. 그런 저희 lifestyle 이런 것들도 자주 애들한테 이야기하는 편이에요. 그런 것들 중에 뭐 하나도 아이들 기억에 남으면 되지 뭐. 친구 문제로 고민한 애들도 있어요. 난 고등학교 때 친구 하나도 안 만난다 평생 친구들을 고등학교 때 안 만나도 된다 지금 외로워도 괜찮다 그런 얘기도 해주거든요. 친구 땜에 고민 했던 중에 어떤 아이는 많은 위안이 (feel comfortable or feel cheer up) 됐다고 말하더라고요 그렇게 그런 것들이도 해결하려고 노력하고. 그래서 인생이 도움이 되는 수업이 되면 좋겠다. 그리고 최소한 추억에 남는 시간이 있으면 좋겠다. 고등학교 때 화학 수업에 또 look back 하면 그 시간에 마치 오아시스 (Oasis) 같았어요 그렇게만 남아도 난 만족해요. (진짜 나에게 꼭 필요한 시간이었어 라고 느끼는 것)
Me: What would you say are your professional beliefs about teaching chemistry? **X:** My biggest goal is get my students had scientific literacy. It looks one of the most fundamental goals. I have made up my mind and decided to express chemistry as a concept which helps improve our life standard another words "chemistry class makes our life better." There are variety of ways that we can make our life better. I think having or obtaining a good range of scientific literacy allow us to read scientific issues in a more logical way rather than reading the situation mechanically. For example, if fake news related to health or science has been launched we should be able to do cross-checking

based on data we search whether that news true or false. As such, whether that news impact on our life or not. We come across different issues in our daily life. For example, in Korea we had an issue to do with "Radon bed mattress" as you know radon is a naturally occurring radioactive material. It is known that it is harmful for human body, company has merchandised. I will give another example. Period pad for women. They also include some chemical ingredient which triggers cancer. You know what I mean, nowadays there are lots of issues happen our society. We need to be careful about them. We need to read how meaningful the unit which contains in the material. For example, how much radon should bed mattress be contained? It is really important to raise awareness among students. In a group activity, among group members there is of course someone who does not like. In that situation, I need to know how to get students engaged with conversation. Sometimes, I want them to write a piece of work about something. It does not matter whether it is scientific or not. I know that writing is very important skill for them. I also introduce film, music, art, beautify scenery. Last year, I watched "A star is born" Lady Gaga, Bradley Cooper" I really loved it. So, I introduced that film to my students and break time I play music etc. My point is what makes our life comfortable is scientific technique but what makes our life rich and fruitful is art. So listening to music, drawing a picture, watching beautiful scenery are ways to make yourself happy. I introduce those sort of things to students so I feel rewarded and worth. In terms of getting students gained chemistry knowledge, I think instructors in cram school/private academy are better than me as they just focus on preparing students for 수능 (College Scholastic Ability Test). I am not that kind of person. I am a person that I want students to feel pleasure of life and have a good attitude to each other. Whenever I go on holiday, I take pictures and videos in there. When I go to the class, I show those places to my students. I love hydrangea the most among flowers. So, when I go to Pusan and Jeju island, I take pictures and show my students. So, I advise my students to live based on what they want. In order to reach your goal what do you need? What kind of job makes you happy or what kind of job take you to reach your goal? I talk to students about lifestyle. I try to give as much example from my live as I could. It is really very good when they remember one of thing that I have said. Some students also worry about not having friends in high school. Then I try to cheer them up saying it is not at the end of the world you can make friends university or wherever you work. if they feel uncomfortable about those sort of things, I try to make them comfortable. That is why I always try to prepare "a class which helps my students' life." Moreover, I want students to remember when they look back to chemistry class as if it was an Oasis. I am really satisfied with it if they remember my class like that.

Appendix 19: Data reduction and initial coding [Sample]

	Questions				
Teachers	Q1: Brief Information	Q2: PD experince (+/-)	Q3: Update of knowledge	Q4: Exchage of knowledge	Q5: Achievement/proud
So-Yeon	C, EdPhD, YoE=17	PLC, PEndv, T, G, Gvt, SS, RG	Pendv, SG, SC, Cors, MeCol, Int, YT, EduMats	Acomty, FB, Oplat,	SA,
Seon-Mi	C, EdPhD, YoE=31, Master	PLC, PEndv, T, G, Gvt, SS, RG, OiS, OoF	Stdnt, Int, EduMats, Dis, Pendv, SNS, YT, Obsv	Prsent, Col, Sha, Acomty, SM, Oplat,	CP, MasT, SA
Sang-Cheol	C, HedT, YoE=31	PLC, PEndv, T, G, Gvt, SS	Int, MeCol, Sha	Acomty, FB, Oplat, Present	CP, SA
Sung-Sook	C, EdPhD, YoE=28	PLC, PEndv, T, G, Gvt, SS, FT	Cors, Pendv, Oplat, Obsv, Sha, FT	Acomty, Oplat, Dis, Int, Presnt, Sha, FT	SA
Si-Eun	C, EdPhD, YoE=14	PLC, PEndv, T, G, Gvt, SS, OiS, OoF	YT, Oplat, Obsv, EduMats, Pendv	Oplat, Col, Acomty, Con, Part, Sha, Wapp	SA, PPD, PhD
Se-Hoon	C, EdPhD, YoE=28	PLC, PEndv, T, G, Gvt, SS	SelfStdy, Edumats,	Oplat, MeCol	PhD
Sang-Woo	P, YoE=13	PLC, PEndv, T, G, Gvt, SS	SelfStdy, Edumats, Pendv, YT, PGR	Col,Com, Part,	SA
Su-Mi	C, EdPhD, YoE=26	PLC, PEndv, T, G, Gvt, SS, RG, OiS, OoF	SG, EduMats, Pendv, PhD, Ctog	Sha, Acomty, Col, Com, Con, Int, FB	SA
Seo-Jun	B, HedT YoE=30	PLC, PEndv, T, G, Gvt, SS	Int, MeCol, Sha, EduMats,	MeCol, Oplat, Sha, Acomty, Wapp, Present	SA
So-Ra	S, YoE=12	PLC, PEndv, T, G, Gvt, SS, RG	SG, EduMats, Pendv, PhD, Ctog	Sha, Acomty, Col, Com, Con, Int, FB	SA
Isaac	C, EdPhD, YoE=10	PLC, PEndv, T, Gvt, SS	MeCol, Wapp, Pendv	Two, Syg, Acomty	SA
Ilana	C, EdPhD, YoE=25	PLC, PEndv, T, Gvt, SS	Sha, FB, MeCol	FB, Wapp, Acomty	SA, ComAw
Ivana	C, EdPhD, YoE=23	PLC, PEndv, T, G, Gvt, SS	Cors, Sha, Engmt, Int, EducMats	Present, TPS, Col, Com, Con, Acomty	Devkit, PhD, PPD
Ioane	C, PhDChem, YoE=5	PLC, PEndv, T, Gvt, SS	Dis, Pendv, MeCol,	Col, Acomty, Cors, Oplat,	SA
Inbar	C, MScChem, YoE=6	PLC, PEndv, T, Gvt, SS	Sha, Obsv, MeCol, Ctog	Col, Com, Present, Acomty, FB, Wapp	SA
Irit	C, EdPhD, YoE=37	PLC, PEndv, T, G, Gvt, SS, OiS, OoF	Sha, Dis, Invt, CwA, Engmt	Sha, Acomty, Col, Com, Con, Int, FB	BT,Part, PPD
Idit	C, EdPhD, YoE=40	PLC, PEndv, T, G, Gvt, SS	Sha, FB, MeCol, Pendv	Acomty, Col, Part, FB, Two	EscR, BT, SA
Ivanka	B, YoE=40	PLC, PEndv, T, G, Gvt, SS	Part, Int, MeCol	Sha, Acomty, Col	SA
Isabel	B, MsBio, YoE=33	PLC, PEndv, T, G, Gvt, SS	Cors,	Sha,	SA, AA
Irene	C, MsChem, YoE= 33	PLC, PEndv, T, G, Gvt, SS	Sha, Wapp	Oplat, Acomty, Wapp	SA
Tolga	C, YoE=15	PEndv, T, Gvt	MeCol, Wapp	Present, Wapp	SA
Turgut	C, YoE=33	PEndv, T, Gvt, SS	Con, Int, EduMats,	Col, Com	SA, BT
Tuba	C, MScChem, YoE=12	PEndv, T, Gvt	Cors	Part	SA
Türkan	B, YoE=30	PEndv, T, Gvt	Dis, PEndv	Con	ExpT
Tülin	C, YoE=22	PEndv, T, Gvt	FT	Ming, SM, Oplat	BR
Tanyeli	C, YoE=7	PEndv, T, Gvt	Wapp, Sha, Pendv	Wapp,	SA
Tezcan	C, YoE=6	PEndv, T, Gvt	YT	Con	No
Temel	C, YoE=17	T, Gvt	PEndv	Oplat	SA, AA
Tamer	C, EdPhD, YoE=7	PEndv, T, Gvt	PEndv	PEndv	BT, SA
Tuğçe	B, YoE=15	PEndv, T, Gvt	EduMats, Wapp, Sha	Wapp	SA, Per
Emma	B, YoE=5	PLC, PEndv, T, INSET, SS	EduMats, Part, MeCol	Twt, Oplat,	SA
Elizabeth	C, EdPhD, YoE=12	PEndv, T, INSET	Ment, Pendv	Col, Dis,	SA

Ethan	C, EdPhD, YoE=15	PLC, PEndv, T, G, INSET, SS, SKE	Aconf,	Sha, Twt, SM, Oplat, Dis	Mchem, Part, EscR, SoS
Emily	C, YoE=8	PLC, PEndv, T, INSET, SS, SKE	SKE, Cors, Ascol, EduMats, Pendv	Dis, Twt	SA, Cteach
Eliot	C, YoE=5	PLC, PEndv, T, INSET, SS	Sha, Obsv, MeCol, Ctog	Part, Acomty, Col, Com	BCT, WAC
Erik	C, EdPhD, YoE=15	PEndv, T, INSET, SS, SKE	Ment, Pendv, EduMats, Con, Dis, Cors, Sha,	Ctog, Twt, Part	Part, Ment, PPD
Eva	C, HedT, YoE=10	PEndv, T, INSET, OiS	Twt, Sha, Ascol, Cors	SM, Oplat, Twt	SA
Elena	B, EdPhD, YoE=20	PLC, PEndv, T, G, INSET, SS, SKE	Ctog, FT, Twt, PhD	Acomty, SM, Twt, Oplat,	AST, SA, Dpro
Emilee	C, MsChem, YoE=27	PLC, PEndv, T, INSET, SS	Twt, EduMats, Sha, MeCol, Pendv, Cors	Twt, Sm, Oplat, Part,	Cteach, SA
Elisa	S, YoE=5	PEndv, T, INSET	YT, Con, Pendv,	Twt, Oplat, SM, Part	SA

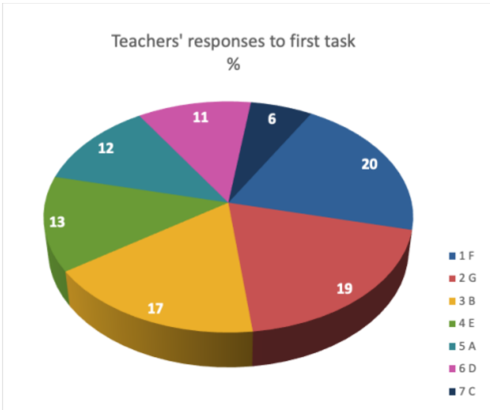
Chemistry: C	Professional Learning Communities: PLC	Conversation: Con	Collaboration: Col	Student Achievement:SA
Physics: P	Traditional: T	Interaction: Int	Communication: Com	Best teacher: BT
Biology B	Government: Gvt	Educational materials: EduMats	Presentation: Present	Personal: Per
Science: S	INSET	Meeting colleagues: MeCol	WhatsApp: Wapp	Expert Teacher: ExpT
PhD in Education: EdPhD	Personal Endavour: PEndv	WhatsApp: Wapp	Participaion; Part	Being rememberred:BR
Years of Experince: YoE	Generic: G	Courses: Cors	Conversation: Con	Chairprson: CP
Master's in Chemistry: MsChem	Subject speciific: SS	Sharing: Sha	Mainling: Ming	Master teacher, MasT
Master's in Biology: MsBio	Research Group: RG	Personal Endavour: PEndv	Social media: SM	Prepared PD: PPD
	Observation in School: OiS	Discussion: Dis	Online prlatforms: Oplat	Microscale chemistry:Mchem
	Out of field: OoF	Free talk: FT	Attending community: Acomty	Publishing article: Part
	Field Trip: FT	YouTube: YT	Feedback: FB	Escape room: EscR
	Subject knowledge Ehancemnet: SKE	Student: Stdnt	Twitter: Twt	Scinece on Stage: SoS
		Study group: SG	Thinh-Pair-Share: TPS	Chartered Collage of teaching: Cteach
		Science contest: SC	Teamwork: Two	Best chemistry teacher: BCT
		Observation: Obsv	Synergy: Syg	Working another country: WAC
		Field Trip: FT		Advanced skill teacher: AST
		Coming togeter: Ctog		Deeloped project: Dpro
		Self-study: SelfStdy		Competition award: ComAw
		Post graduate room: PGR		Developed kit: Devkit
		Attending conference: Aconf		
		Asking colleagues: Ascol		
		Mentroing: Ment		
		Engagement: Engmt		
		Invitation: Invt		
		Coorporation with academic: CwA		

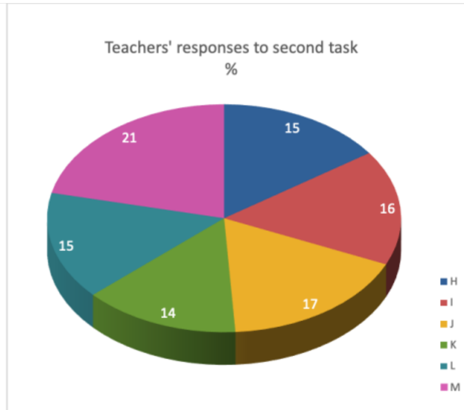
Appendix 20: Summary- Focus group interview

Focus Gorup Interview

Date	Number in order	Teacher	1st Task Answer							Reason	2nd Task answer						Reason
24.09.2019	1		6	5	4	1	3	2	7	Teacher's beliefs about providing knowledge is important. I should teach based on what they need. Thereafter, teacher's professional knowledge comes. In order to improve skills about "students' need" and "knowledge matter" collaboration is necessary	6	4	5	3	1	2	My beleifs about providing knowledge is different than what I have been taught at univerisity because we have been educated traditional way. Therefore attending PD is quite important to update my knowledge matter.
	2		5	2	4	7	6	1	3	Basically, what is the most important issue in relation to education is to teach how to have a good character and personality, in addition to subject knowledge. At high school level, it is better to teach students various knowledge rather than get them taught in deep knowledge. From my point of view, gatheing with other teachers in PD activity is also important to share ideas between us where we can learn different teaching skills	4	3	5	6	1	2	**4. Collaboration:** Collaboration between teachers makes the education more effective. **3. Personal Value:** Students could be gained common sense and thoughfulness through education so teachers' personal value impacts on it. **5. Professional knowledge:** it is important to provide students with new instructions and improve some strategies for better teaching **6. Belief:** Teaching is the reason of my exsitence in the classroom
	3		6	7	5	1	4	2	3	I think that teacher shoud be responsible for giving students opportunities and broadon their learning environment to discover knowledge by themselves	4	2	1	3	6	5	**4. Collaboration:** Making students knowledgeable is not enough. Knowledge should be cherised by the collaboration of others. **2. Self-refelction:** Every class, when I finish the class I reflect how much I do interactio with students. **1. Go the extra mile for students:** I always find intersting and variety of videos and other materials for students. **3. Personal Value:** I would like to teach my students how to live together happily and peacefully.
	4		6	4	7	2	5	1	3	I think scientific knowledge is important to get students gained proper and logical decision making, which is important to attend democratic society	3	6	5	1	2	4	**3. Personal Value:** I would like to investigate nature with my students by coming together and get them gained logical thinking ability and broaden their horizon. **6. Professional belief:** I would like to be a mentor for my students to motivate them. **5. Professional Knowledge:** I improve myself by watching scienftic videos on YouTube. I also attend workshop to update myself. **1. Go the extra mile for students** I am attending PD activities to get new information then adopt it in my class. although it is not mandotary, I am attending it to give update information to my students.
	5		2	6	7	5	1	4	3	Building a strong community and doing it consistantly should be one of the main aim of education. Providing students with an environment where they can discover by themselves is also important. Therefore, teachers are also responsible for on their own professional development	3	2	4	5	6	1	**3. Personal Value:** As students learn more, I feel satified and happy. **2. Self-reflection:** I designed my lesson based on my students' exam results and their performance. **4. Collaboration:** I share information based on what they need for living sort of life coaching. **5.Professional Knowledge:** I attend PD and other activities for updating my knowledge matter.
11.10.2019	6		6	7	2	4	5	1	3	It is not that much effective to know basic knowledge in this 4th generation industrial revelotuion. What it makes sense is to formation of knowledge is important based on knowledge which is gained	5	2	4	1	3	6	I learn the information that I have lack of through communities. Before the class, I put effort to cover everyting ralted to what I will teach. So, asking other teachers and reflect on it is important.
	7		6	7	5	4	2	1	3	As I get to kno about the application of science, concept of sceince and principle of science, I realised the importance of study, practice and practility of chemistry in daily life.	6	1	5	3	2	4	It is important to provide pychologcical and physical environement where the knowledge is obtaind. Moreover, motivtion is important
	8		7	6	2	3	1	4	5	The biggest impact on teacher's identity is to properly define to do with what teachers should be responsible for and what teacher should be repesent for students.	6	3	2	4	1	5	Tachers' beliefs and values impacts on how they teach what they teach and how to teach.
	9		6	7	2	1	4	5	3	Teacher's belif is the most important issue in education. Teachers should teach the value of knowledge rather than memorasing of the knowledge. therefore, teacher should motivate to students to gain knowledge by themselves. Teacher should improve on his own professional knowldge. it is important to meet and share knowldge but teacher should filter the knowldge based on critical judgement ability.	2	6	1	4	5	3	Self-reflection comes first which shapes beliefs and motivates teacher to go further.
15.10.2019	10		2	4	7	6	5	1	3	Since science education cannot be seperated from society, education for raising good citizen is the most important in education.	6	2	1	3	5	4	**6. Belief:** It is important because it leads you where you go in detail. **2. Self-reflection:** teacher who has self-reflection ability can improve himselves. **1. Go the extra mile for student:** if you do that, student feel motivated and respect you.
	11		2	7	6	1	3	4	5	One of the most important aims of education is that students should be taught to be positive and they are precious and main character of their life rather than anyone else.	1	2	3	6	5	4	Teacher should go the extra mile to make them motivated and make the science enjoyable. Students should see what you are doing for them. Thereafter, your beliefs and values about teaching shape students' mind
	12		2	7	1	6	5	4	3	School is a place where is connected to society. Students are getting knowledge and make it related to society. teachers in this persective have very importantn role in students' achievement by providing them with variery of perspective and knowledge. teachers are also teaching different approaches to make them successful.	6	3	1	5	2	4	Sharing my goals and aims about topic that I teach to students is important. When they get what I try to teach , I feel satified. Therefore, I make sure what I have taught and what I intend to teach. So reflection on what I will teach based o the previous classes is important
	13		7	1	2	3	5	6	4	Teachers' attitude is important to form his professional identity.	3	2	6	1	5	4	**3. Personal Value:** Raising students with logical thinking skills for democratic society is real aim of education. **2.Self-reflection:** getting feedback is important to update wheter I teach well
22.10.2019	14		5	1	6	7	2	3	4	Having strong subject knowledge for science teaching is very important.	5	4	1	3	2	6	**5. Subject Knowledge** comes first which is supported through PD. **4 Collaboration:** getting new ideas from others to teach different subject is important as they have different point of view. **1. Go the extra mile:** Doing practical activities and finding different videos for students are useful.
	15		2	7	1	3	6	4	5	First priority of education is to raise excellent global citizen. Other themes all of them serve to raise a good citizens.	6	5	4	3	2	1	**6. Belif:** Interaction with students leads to provide benefits both teachers and students so it should not be top-down approach between students and teachers. **5. Professional knowledge:** attending PD and sharing experince to each other are important to excelatre knowledge matter. 4. Collaboration: Thinking collaboratively provides different perspective and let me catch up differnet teaching strategies. **3. Personal value:** Providing students with knowledge, emotions and willingness should be aim for better education
	16		6	7	2	4	1	5	3	teacher's belief and his philosophy are important because based on what they have belived their teaching can change.	6	4	1	5	2	3	The belief that I get as a teacher is to make students interested in curious while teaching science
	17		6	2	5	7	4	1	3	I listed the statemets based on my beliefs and philosophy on education. Rather than teaching chemistry to students, I prefer to teach how enjoybale the chemistry is. If they grasp the motivation behind chemistry and principles of chemistry, they will learn better	6	3	2	1	5	4	**6. Belief:** Sincere heart about whatever you do brings success **3. Personal Value:** It is important to raise students who think critically and anaylitically. **2. Self-reflection:** I become more reflective as I read, write self blog and collabotare with others.
	18		6	7	5	1	3	2	4	What I think the most important is that having a proper belief about what should be the role of teahcer rather than result. Because if you have a belief to make students successful, then result would be great and pozitive so belief impact on what you will do and expect	6	5	2	4	1	3	It is important to teach the subject to students the easiest way possible which requires great subject knowledge

Number	1st Task Themes	2nd Task Words	
A=1	**Attending professional development**	**Go the extra mile for students**	H=1
B=2	**Raising responsible citizens**	**Self-reflection**	I=2
C=3	**Government intervention on teachers' professional development**	**Personal values**	J=3
D=4	**Collaboration for better academic outcomes**	**Collaboration**	K=4
E=5	**Teachers' professional knowledge**	**Professional knowledge**	L=5
F=6	**Teacher's beliefs on providing knowledge**	**Beliefs**	M=6
G=7	**Teachers' responsibility/role**		





***** Pie charts above has been designed based on point-based system.**

All themes and words in task 1 and task 2, respectively have the same importance. So they are not superiority to each other but teachers' priority leads me to design pie charts to understand which theme and word are more important than others.

1. Grants the highest score sequentially, starting with the highest priority.
2. For each respondent, multiply the selected answer by the assigned score.
3. The sum of the scores added by each item was calculated, the differences between the items were analysed and expressed in percentages.

Appendix 21: Example of transcript of classroom observation- Tolga in Turkey

Teacher: Naming covalent compounds

Teacher: I will give a formula and we will keep continuing in this format. Actually, the rules that I mentioned while teaching naming ionic compounds are valid to name covalent compounds. There is expression called "prefix" which indicates "numbers". These numbers come from Latin. So where does the numbers come from?

Students: From Latin.

Teacher: Okay my friends, Let's get started. Please tell me Latin numbers.

Students: 1. Mono 2. Di 3.Tri 4.Tetra 5. Penta 6. Hexa 7. Hepta

Teacher: You are excellent

Students: 8. Octo

Researcher: Students have said the Octo silently then teacher want them to say it loudly.

Students: 9. Nona 10. Deca. 11. Undeca

Teacher: I could not hear

Students: 12. Dodeca

Teacher: I could not hear say it loudly please

Students: 13. Trideca 14. Tetradeca 15. Pentadeca 16. Hexadeca 17. Heptadeca 18. Octodeca 19. 20.

Teacher: It is not necessary to memorise all of them but grasp the idea behind how Latin numbers are named. Apart from 11 and 12, from 13 to 19 we just add "deca" as a suffix. When we call 11 we say "Undeca" and 12 we say "Dodeca". There is a one golden rule friends. No prefix is added to the first element's name. if there is only one atom of the first element in a molecule. What I am trying to say is that when we name CO, we will not say mono carbon, instead we will say directly carbon monoxide. Did you get it? is there any problem?

Students: Nope

Teacher: Let's write it down.

Researcher: Teacher wrote down Latin numbers starting from 1 to 19. Thereafter, he wanted students to copy what he has written on the board. (3.58-5.22)

Teacher: I want also to read the covalent compounds that I have written on the board.
Teacher: Let's start reading friends. I will first erase these part then keep reading. Let's start reading. You Busra Could you read CO_2 ? and You Merve coud you read N_2O ?

Student 1 (Boy): Carbon dioxide

Student 2 (Girl): Dinitrogen monoxide

Teacher: Let's read this one together N_2O_5

Students: Dinitrogen pentoxide

Student (Boy): Do we apply to grammar rules here as well?

Teacher: Yes. When we read them, Turkish grammar rules apply to.

Teacher: Hmm what I can write? Okay let's say CS_2

Student (Boy): Carbon di sulphite.

Teacher: These students are studying in science high school so as long as they see the rules, they just learn so I do not have any difficulty while teaching. they just learn whatever I teach. Okay my friends did you write down all things on the board? (7.00-9.07)

Teacher: Now let's say the name of the compounds and then write down the formula. Let's say Sulphur hexafluoride. So I have sulphur so I have written "S" then I have fluorine so I written "F". so I have a hexa prefix, which refers to 6. So formula of this compound is SF_6 Let's make up another compound. There is not such a compound but I just make up in order not to repeat those I have written before. Di sulphur tetra oxide. So I have two sulphur and four oxygen then the compound would be S_2O_4

Teacher: Then what is your name my friends?

Students: Fevzi and Emir

Teacher: Tri Fevzi Hexa emir

Researcher: All students are laughing

Teacher: Let's name it this compound ☺

Teacher: So did you understand the logic behind how to name covalent compounds? (10.45-11.40)

Teacher: Is there any point that is not clear my friends? Everybody got it? As you know, you will get question from naming compounds in the exam. I will also ask question in the mid-term exam.
Teacher: Let's get a move on Metallic bonding. Let's remember when we talk about metal, we need to remember periodic table. we need to think about metals, which are located in group 1A, 2A and 3A. After 3A, what is next? 4A. starting with 4A, non-metals are located in 4A, 5A, 6A and 7A. and Last column belongs to noble metal, which is 8A group. Let's repeat what we have in group 1A,2A, and 3A?

Student (Boy): Metals

Teacher: As you remember we talked about the size of the atom in the periodic table. In the periodic table, what happen to the size of atom when we cross from left to right across a row?

Student (Boy): Atomic radii decreases

Teacher: Yes definitely. It decreases. Then we can say that the size of metal atoms bigger than non-metal atoms. There is an saying in Turkish, which is "out of sight out of mind" another words as the size of atom increases, the gap between core and electrons is also getting bigger. Therefore metal atoms do not pull its electrons in outmost shells as strong as non-metals do. As you can understand, outmost shells electrons tend to be free. How it is?

Students: Free

Teacher: Another way to say those electrons are a bit cool and look forward to hanging out. I wish this subject would have taught after the orbitals. But you will learn about orbitals at grade 11. Since you do not learn about orbitals, I try to give simple examples to make you imagined what it looks like. I am going to draw it now. Let's say there is iron here, there is another iron there, which are charged "+" I am just drawing randomly. And let's say there is an aluminium here. What is atomic number of Al?

Students (Girl): 13

Teacher: When you look at electron configuration of Al, 2,8,3, it means there are 3 electrons at the latest level. Those 3 electrons are a bit free. What I have tried to say is that those 3 electrons are not pulled strongly by core nuclei. As you can guess, those 3 electrons circuit around the orbit. They behave as if they belong to one nuclei. Those outmost electrons do not behave as they belong to one instead the behave as they belong to nucleus. As you see, they look like swimming in the bulk of electron sea/lake or cloud etc. I gave you three different terms electron sea, electron lake or electron cloud because in textbook you will see those terms. For example we also have a term "active electron", which is eager to leave. You can come across different terms to describe the same situation but you do not need to be nervous when you see different definition. But my friends it is not as easy as you think. Now, I would like to explain how those characteristics of metal atoms at outmost level impact on our life. Actually, it brings about some interesting cases. You will ask Like what? You go to the sink and get closer your hands to tap, then water starts to come and you get your hands back from the tap then the water stops coming. Before you come to door, the door is opened and after you pass the door, the door is closed… but the worst thing is when you go to the toilet, if it is a photocell lamb, you always shake your hand ☺

Students: they are laughing

Teacher: My friends, those electrons are hold on so weak that even sun light brings about flying those electron from the electron shells. So easily

Student (Boy): then there are countless electrons around us aren't there?

Teacher: Yes you are right. We are living together with them. we expose to electrons right now. Thus, we need ourselves to be neutral by washing our hands and face and we take a walk on bare foot on the ground. So, what is the principle of photocell light? What I want is that the streetlights turn on and off automatically. When it gets dark, they are on and when it gets light, they are off. What I need to do is to put here a photocell. When I put a photocell in this circuit, + and – charges flow through this way instead of that way it means electrons choose the easiest way to complete the circuit (short circuit). When the photoelectric sensor emits the light, short circuit happens and light is off. It is same for sink faucet and doors etc. this is because of the eagerness of electrons at the outmost level.

Let's look at another characteristic of metallic bonding. Metallic bond is strong. Why does it so? Because nuclei is always interacting with electrons as they are everywhere. We also know that metals conduct electricity. Why does it so? It is because of delocalised electrons. What I am saying is when you supply energy from here, it reaches anywhere that the metal is available. Metals also conduct heat because The **electrons in metal** are delocalised electrons and are free moving electrons so when they gain energy (heat) they vibrate more quickly and can move around, this means that they can pass on the energy more quickly. As you know, ionic compounds are brittle easily. Ionic crystals are hard because of tight packing lattices, say, the positive and negative ions are strongly attached among themselves. So, if mechanical pressure is applied to an ionic crystal then ions of similar charges may be forced to get closer to each other. Now, by doing so, the electrostatic repulsion can be enough to split or disorient completely the lattice infrastructure. Thus imparting the brittle character. However, metals are not broken. When you hit the metals, the electrons are still everywhere and metals keep their structure. You can bend it because everywhere is a sort of electron sea. Therefore, nuclei is never pushed each other they pull each other because + and – charges are come together. So they will not be broken but they can be bent and shaped.

Teacher: So did you get metallic bond? Is there anyone does not understand? Then let's start writing about what I have said.

Appendix 22: Transcript of Professional development activity observation in South Korea

0.00-5.00

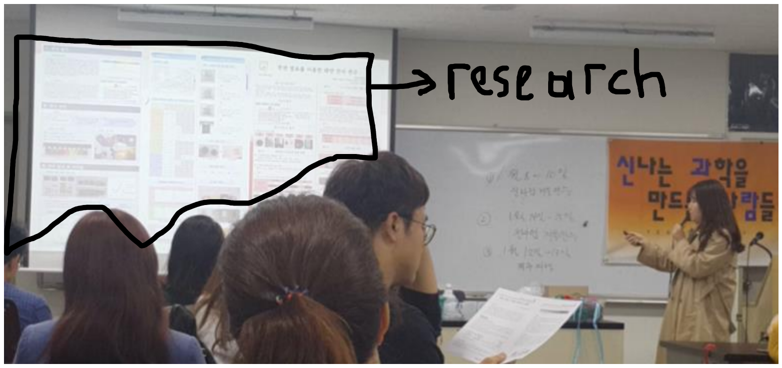
Presenter: So far, we have talked about plastic. (Sarcastically) She is saying; Today we plan to produce large amount of plastic waste, which is not good for our environment☺

Observer: Everybody is laughing

Presenter: It is not perfect but today I explained a research that I have done with my 11th grade students. The research was about how we could create more eco-friendly environment. Today's topic is to make a flexible electrode by using slime.

Lately, I have done this experiment and other chemistry teachers have said to me like that. "Do you like battery?" Actually, if I think deeply, I have been doing experiment just based on battery☺. Before I got into teaching, I worked in the laboratory and was interested organic solar cell. Therefore, dye-sensitized solar cells were the topic that I tried to get engaged students with latest trend by doing experiment and developing project. This year I am keeping doing the experiments.

Observer: She keeps explaining what kinds of research she has done so far with students.



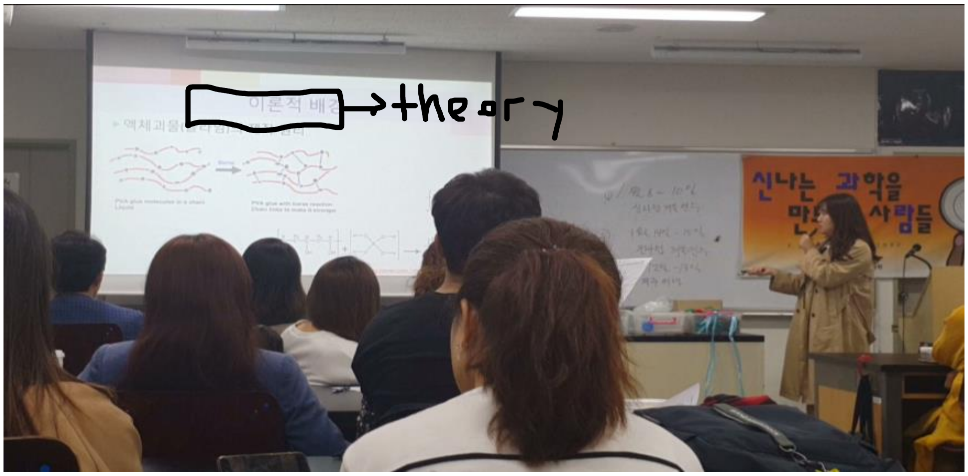
5.00-10.00

Presenter: Flexible electrode is new area to investigate. The reason why I am interested in this topic is when students go to science exhibitions, they get some ideas from there to develop on their own research. In that time there was a research which was about measuring electrical conductivity using gum. Last year, I had students who were interested in making slime. So I ended up with doing a research about slime and battery. I made electrode and measured electro conductivity using slime and gum. Today, I am here to make a flexible electrode using slime with my colleagues.

It is easy to understand what the polymer is using familiar materials. Before I got here, I had a look at textbook but the polymer was not in the context. As a teacher who teaches polymer and knows how important they are as you know this year Nobel chemistry prize went to a research about lithium battery. So I planned to do the experiment about battery.

Actually, polymer does not conduct the electricity. It is rare to find an electroconductive materials among carbohydrate. But nowadays materials are designed to conduct electricity. Today, I am plaining to make an electroconductive material by mixing metal with slime.

When it comes to how to make a smile, generally liquid glue mixed with soda lime and contact lens solution. If you put the glue, it becomes strong. Here it is I will explain theoretical background behind slime.



Presenter: I got this content from Seon-Mi, who is a founder of Teacher collaboration centre I. She is writing a science blog. She is also uploading content related to chemistry content.

When it comes to PVA, while doing experiment with PVA, the problem with that is melting very fast when it comes across with water. Actually, I failed a lot while doing but as I do, I got experience and I become better and better.

Slime is stuck to hand, if you put it, electric is conducting but as soon as it has gone. In fact, slime is soft and slimy but today we will make rather hard and tense electrode. I thought putting slime into disposable pipette would be a great idea but pipette is so narrow that it would not allow electricity to get through. Instead, I put directly into aqueous solution to flow electric current effectively. This is where oxidation reaction takes place. We plan to generate electric using zinc and copper. Since, Zinc is better oxidized than copper, we will use oxidation-oxidation reaction. We will make the Daniel cell. Zinc is oxidized and when it is connected with the leading wire, a reduction reaction occurs in copper to produce electric. I am going to put a salt bridge in the middle here, and it serves to balance the ionic imbalance caused by the redox reaction, and keep it neutral on a regular basis. I usually use this salt bridge. That is why, I was going to use this salt bridge, but I found out that the filter paper has the property of absorbing water, so even if you put electrolyte in the filter paper, it acts as a salt bridge. I searched and found a slime flexible electrode making kit.

10.00- 15.00

So, here it is equipment for the experiment, there is a tool, which I can insert slime into hole. In both side, We can insert zinc and copper and connect them through salt bridge then check it whether electric is flowing or not.

15.00-45.00

Observer: She is explaining detail about the experiment.

Presenter: I am going to put slimes into empty slots to make the electric current. You are going to make each of these tiny electrodes (as it seen in the ppt). this is what the final version to be seen. If we just talk about the conclusion, you need to connect two series circuit to make a sound. We will listen to the sound first using the melody kit. I have tried four times and all of them were the same.

So, let’s come here and get the tools and equipment for the experiment.
Observer: From now on, teachers as a group of 4 to 5 started to do experiment as the presenter explained.