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Popular Culture of Mathematics through Ancient Greek Old Comedy

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Dissertation submitted as part of the requirement for the Degree of Master of Arts by Research in Classics
at Durham University, in 2021

This dissertation explores the extent to which mathematics played a role in comedy of fifth and fourth century BCE Athens. Within the corpus of Aristophanes and the fragments of Old Comedy, jokes about or implementing mathematical concepts occur. Analyzing the effects of these jokes sheds some light on how the audience of these comedies viewed mathematics and what sorts of mathematics were taken as common knowledge. Jokes containing references to calculation and common measurements indicate that the audience was to some extent numerate and had the ability to convert measurements relatively easily. Additionally, although references to specific mathematicians in Old Comedy are scarce, it seems that the audience was presented with a caricature or otherwise skewed picture of named mathematicians when they were mentioned or, in the case of Meton, brought on stage. Meton's identity in fact seems to have been further mutilated by later scholars, as the passage in *Birds* does not relate Meton to the kind of mathematics for which others like Euclid would become known, but scholars have insisted that it does. Overall, mathematical jokes show that mathematics could be used both for good and for evil, and often they pack the same punch as the political jokes for which Old Comedy is famous.

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Introduction

Mathematics, to many people in our modern world, has a strong connotation of objectivity. Not just scientists, but historians, politicians, and even advertisers all make use of the perceived objectivity of mathematics to make their arguments stronger and to bolster their own appearances of objectivity. Accordingly our knowledge of mathematics affects our ability to interpret these arguments, and an audience's lack of mathematical knowledge can become an often-exploited weakness. Thus mathematics has the power to sway great numbers of people, even if the math itself is not sound. But was that as true of antiquity as it is of the present?

It has already been argued that mathematics had such power in the ancient Mediterranean. Specifically in the context of ancient Greece, Serafina Cuomo has noted that in classical Athens public inscriptions of government financial records were erected to display how public funds had been spent,¹ and Tazuko van Berkel has argued that oral calculations in Greek oratory, especially in the speeches of Lysias and Demosthenes, gave the orator an air of authority by showing off their impressive mathematical capabilities.² But it is also clear that mathematics in ancient Greece retains an image of exclusivity. Plato, according to later sources, chastised his students for solving the Delian problem of doubling the cube with the aid of newfangled, practical instruments rather than by compass and straightedge alone, the only tools allegedly allowed in “pure,” and by implication “elite,” geometry. How can we square the idea of “pure” mathematics with its use in public, collective contexts?

With these ideas in mind, I propose to examine references to mathematics and to the types of people who used it in the corpus of Greek comedy, which Aristotle deems in his *Poetics* μίμησις φαυλοτέρων, “a representation of the lesser” (we can also note the use of elitist language here by Aristotle in the word φαῦλος, i.e. “common”, “trivial”, which he also uses to describe people, actions, and topics associated with “cheap” works). Through events like the Dionysian festival in Athens, comedy reached a wide and engaged audience across society, and it often included public commentary on political, philosophical, and social themes.

An analysis of comedy with a focus on mathematical references and practices will help to fill the current gap in literature concerning the non-elite views of mathematics, giving us a more

¹ Serafina Cuomo, “Accounts, Numeracy and Democracy in Classical Athens,” in *Writing Science: Medical and Mathematical Authorship in Ancient Greece* (Berlin: De Gruyter, 2013), 255-275.

² Tazuko Angela van Berkel, “Voiced Mathematics: Orality and Numeracy,” in *Voice and Voices in Antiquity: Orality and Literacy in the Ancient World*, vol. 11, ed. Niall W. Slater (Leiden: Brill, 2017), 321-347.

complete and inclusive view of mathematics in ancient Athens, and potentially beyond. This study will focus on the corpus of Old Comedy: a particular focus on Aristophanes is inevitable, considering the state of the other authors of Old Comedy, but the fragmentary authors will be discussed and will provide alternative ways to approach Old Comedy. In analyzing these works and fragments I hope to answer the following questions:

- 1) Is mathematics mentioned in order to critique mathematics itself, or the people and institutions which use or misuse it?
- 2) How was the audience of comedy expected to react? Was mathematics as a whole viewed in a positive or negative light?
- 3) To what extent were the audience and writers of Old Comedy familiar with the works of mathematicians? How experienced with mathematics was the Athenian audience?

Answering these questions may help to shed light on whether the image of exclusivity we saw above in connection with Plato was shared by the average Athenian, as well as to what extent they thought mathematics was used by the elite as a weapon against them. These questions require a deeper understanding of how the public interacted with mathematics, and ancient Greek comedy is an ideal genre to gain this understanding: comedy, in addition to its references to math, has a deep connection to religion, both in its content and its context, so studying how math and religion interact within this genre will help guide further research into their associations with each other. In this way the current study can serve as a stepping stone to further inquiry about math and religion in the ancient world.

0. Literature Review

Scholars have been writing about Aristophanes's comedies for ages, and there are certainly no signs of them stopping. Mathematics has received comparatively less attention from mainstream scholars of the ancient Mediterranean, but certainly is not untouched. The overlap between these two, however, is scant: over the past century, while interest in Greek mathematics outside of the circle of "theoretical" mathematicians has been growing, only a few articles use comedy to try to answer questions about the average Greek-speaker's interactions with math. This is not due to a lack of source material, although admittedly there is not much to go on. Scholars of comedy frequently point out Aristophanes's inclusion of Meton, the mathematician and astronomer, in *Birds* to highlight the attacks Aristophanes makes on intellectuals, but rarely delve deeper than this. Is this really all we can say from that scene? With more insight into the language of mathematicians, it seems reasonable that the answer is no. Jokes about mathematicians also extend outside of the realm of Aristophanes, so there must be more to these jokes than just a simple stab at sophists or intellectuals.

Comedy in the fifth and fourth centuries BCE has provided much insight into daily life in Athens. Victor Ehrenberg's *The People of Aristophanes* gives a comprehensive overview of farmers, nobility, war, money, trade, slaves, religion, and foreigners in Athens as seen from the point of view of comedy. More recently, Alan Hughes's *Performing Greek Comedy* provides a trove of knowledge from not just the comedic texts, but also archaeological sources, detailing aspects of society, stage mechanisms, and even actors' and actresses' gestures. Yet both of these seemingly overarching works seem to neglect the mathematician; what is worse, they further conflate the appearance of mathematicians with those of other intellectual groups, especially the sophists, often with the effect of erasing the separate identity of mathematician entirely (e.g. Ehrenberg: "The inclusion of Meton amongst the impostors is, of course, to be attributed to the same attitude of mind in the poet which made him depict Sokrates as a mere sophist and an observer of the stars. To Aristophanes intellectual pursuits were as wicked a source of economic gain as politics").³ This seems contrary to how mathematicians in the real world viewed themselves in relation to other intellectuals, as Netz and Asper have argued in "Greek Mathematicians: A Group Picture" and "The Two Cultures of Mathematics in Ancient Greece", respectively. Both scholars argue that mathematicians were generally set apart from other

³ Victor Ehrenberg, *The People of Aristophanes: A Sociology of Old Attic Comedy* (Oxford: Blackwell, 1943), 45.

philosophers, and in fact actively tried to distance themselves from the dreaded sophists of the time. So it seems strange and even wrong to lump them into groups with which they themselves may not have identified.

Scholars of Aristophanes have not done mathematicians much better justice. As mentioned above, most of the focus on mathematicians comes down onto Meton in *Birds*. Two scholars, Wycherley and Amati, have written about this particular scene in the past century. Wycherley's work is mostly a detailed commentary on the lines, while Amati goes a bit more into how the scene fits into the play as a whole. From Wycherley's commentary, it seems that scholars have been, rather than delving into the actual portrayal of a mathematician, trying to understand the lines themselves. His overarching questions throughout the commentary are "What do Meton's lines mean and what precisely does he do?", referring to the actions described in the lines.⁴ After explaining with diagrams what he thinks Meton draws in these lines, Wycherley concludes:

Aristophanes' primary object [with this scene] is to poke fun at Meton; since Meton is a mathematician and since a city is in building, the most appropriate thing he can do is to draw a geometrical figure which will serve as a town-plan. I should hesitate to ascribe any further motive; at most I would tentatively suggest that Aristophanes, having heard vaguely of the idea of reducing a town's streets to a set scheme, considers it new-fangled, fanciful, and unpractical, applicable in fact to the air.⁵

This is hardly more insight than Ehrenberg and Hughes provide. Wycherley hesitates not without reason, but he does not compare the language used by Aristophanes to portray Meton with the language actual mathematicians used. Perhaps Meton's actions parody those of a literal geometer (i.e. a land-measurer), but his words do not reflect the register of theoretical mathematical texts,

⁴ R. E. Wycherley, "Aristophanes, *Birds*, 995-1009," *The Classical Quarterly* 31, no. 1 (1937), 22.

⁵ *Ibid.*, 31.

which are generally known for their impersonality.⁶ So there is certainly more to be gleaned from this scene than Wycherley's conclusion.

Amati writes about the same scene, putting his focus on how Meton fits into the play as a whole. After pointing to passages which, he argues, foreshadow Meton's proposition to plan the city in the sky,⁷ he goes through the same analysis as Wycherley.⁸ Finally he ends with all the reasons Meton's proposed plan could never fit into Peisetairos's plan for his city in the sky.⁹ Amati's main conclusion is:

Meton's attempt to draw a 'map' of this polis represents the imposition of πολυπραγμοσύνη ["meddlesomeness"] on the comic hero's freedom to do as he pleases. Meton's Nephelococcygia reproduces the aspects of the terrestrial Athens that Peisetairos hates the most: streets, which permit contact with other localities; private property, which leads to inequality of wealth; and the agora, with its capacity to entangle citizens in πράγματα ["affairs"]. Meton has to go.¹⁰

This conclusion is at least something not found in the other sources thus far, but still seems to ignore Meton's identity as both astronomer AND mathematician. Despite going beyond what Wycherley set out, Amati still barely touches on the implications of Meton's identity as a mathematician, and instead focuses on the meaning and theatrical execution of the lines in question. Once again, while the execution of these lines is interesting and relevant to questions of mathematicians' image in comedy, it is not the be-all end-all.

Putting comedy aside, we now turn to scholarship written from the perspective of history of science and mathematics. Much of this writing in fact focuses on the history of mathematics vis-à-vis Plato and Aristotle. David Fowler's *The Mathematics of Plato's Academy: A New*

⁶ See Markus Asper, "The Two Cultures of Mathematics in Ancient Greece," in *The Oxford Handbook of the History of Mathematics*, Oxford Handbooks (Oxford, New York: Oxford University Press, 2008).

⁷ Matthew Amati, "Meton's Star-City: Geometry and Utopia in Aristophanes' *Birds*," *The Classical Journal* 105, no. 3 (2010), 213-218.

⁸ *Ibid.*, 218-222.

⁹ *Ibid.*, 222-226.

¹⁰ *Ibid.*, 226.

Reconstruction is very valuable to the field of history of math, and Fowler does bring up ancient Egyptian calculation methods and records, but the book does not touch the question of how an average Athenian resident would conceive of mathematics.¹¹ Rather, the book's main purpose is to theorize a more deeply-embedded use of anthypharesis across "theoretical" mathematics based on its appearance in Plato's *Meno*. As another example, Phillip Horky discusses the defining characteristics and factions of "mathematical" Pythagoreans in *Plato and Pythagoreanism* and their relationship with μαθήματα.¹² However, Horky's analysis depends mostly on information from Aristotle (chapters 1 and 2) and Plato (chapter 4), and otherwise on later scholars whose information is at best second-hand. In *Ancient Mathematics*, Serafina Cuomo goes so far as to say Plato and Aristotle "were less interested in providing an accurate depiction of contemporary mathematicians and mathematics than they were in making philosophical points,"¹³ which is certainly proved in the often-cited passage in Plato's *Meno* with the enslaved boy and Sokrates. Moreover, the conclusions drawn in Horky's book about what aspects of mathematics characterized each faction of Pythagoreans are hardly extendable to the Athenian public by and large, as the Pythagoreans, while familiar to at least some of the Athenian public, did not constitute a large proportion of it. Thus this vein of literature about ancient mathematics is lacking in two respects: first, it in general has nothing to do with the common Athenian public, and, second, it depends on sources that for the most part post-date the time period we are interested in (the fifth century BCE).

More has been written about mathematics outside of "theoretical" mathematics in the recent decades than ever before,¹⁴ and this new path in the history of mathematics has tried to plug the holes left by the kind of literature mentioned in the previous paragraph. Scholars including Markus Asper, Serafina Cuomo, and Reviel Netz have turned the focus onto the average ancient person and their relationship with mathematics, and we will discuss some of their theories and conclusions in the next chapter. Yet few have taken a deep dive into comedy as a source for popular views of mathematicians, either of the "theoretical" or "practical"

¹¹ David Fowler, *The Mathematics of Plato's Academy: A New Reconstruction* (Oxford: Clarendon Press, 1999).

¹² Phillip Horky, *Plato and Pythagoreanism* (Oxford: Oxford University Press, 2013), see especially chapters 1, 2, and 4.

¹³ Serafina Cuomo, *Ancient Mathematics* (London: Routledge, 2001), 5.

¹⁴ See J. J. Coulton, "The Dioptra of Hero of Alexandria," and L. Taub, "Instruments of Alexandrian Astronomy: The Uses of the Equinoctial Rings," in *Science and Mathematics in Ancient Greek Culture* (Oxford, New York: Oxford University Press, 2002).

varieties.¹⁵ It is clear that numeracy has been used as a tool of persuasion in ancient Athens, as demonstrated by Cuomo's writing on Athenian record inscriptions, which in fact is one of the few instances where a scholar has used comedy to illustrate mathematics among common Athenians,¹⁶ and van Berkel's writing on "mental" calculations in rhetoric.¹⁷ So why have so few thought to look at the persuasiveness of numeracy and mathematics in comedy? More generally, considering comedy's proximity to the general Athenian public, it seems to be most likely to contain information about how an Athenian resident would conceptualize mathematics and those that practiced it, yet our current conceptions of ancient mathematics are still largely based on Plato and Aristotle. Therefore, in light of the literature discussed above, this study seeks to expound upon ancient mathematics through its receptions in Athenian Old Comedy, so that we might better understand how the general public of ancient Athens would have conceived and viewed mathematics. However, before we can conclude anything about ancient mathematics, we must first discuss what could constitute mathematics in ancient Greece, to which we will move in the next chapter.

¹⁵ See Reviel Netz, "Greek Mathematicians: A Group Picture," in *Science and Mathematics in Ancient Greek Culture* (Oxford, New York: Oxford University Press, 2002), and Asper, "The Two Cultures," on "theoretical" vs. "practical" mathematicians.

¹⁶ Serafina Cuomo, "Accounts, Numeracy and Democracy in Classical Athens," in *Writing Science: Medical and Mathematical Authorship in Ancient Greece* (Berlin: De Gruyter, 2013), 255-275.

¹⁷ Tazuko Angela van Berkel, "Voiced Mathematics: Orality and Numeracy," in *Voice and Voices in Antiquity: Orality and Literacy in the Ancient World*, vol. 11, ed. Niall W. Slater (Leiden: Brill, 2017), 321-347.

1. What constitutes “mathematics”?

Most of us probably think we have a good idea of what constitutes “mathematics” in modern times. Few would argue a statement like “ $1+1=2$ ” would not fall under the category of mathematics. However, the verbiage we use to describe our idea of mathematics depends on how deeply we have studied it: for example, many would recognize “addition” and “subtraction” as mathematical topics, but perhaps not “groups” or “rings”. Without specialization in modern mathematics, someone is not likely to understand every reference to it from someone who is specialized. Thankfully, most of the higher-level mathematics studied in universities (and increasingly even in high schools) was not known in the ancient world, so it can be ignored for the purposes of this paper.

That being said, most scholarship on ancient Greek mathematics up until the 1970s seems to investigate how our ways of performing modern mathematics (i.e. everything we know and understand about numbers, figures, areas, volumes, algebras, etc.) maps *onto* ancient Greeks’ ideas, i.e. trying to morph Greek mathematical texts into modern terms. Scholars do this for good reason: it is the much easier way. Simply assuming that ancient Greek mathematicians knew and used algebra but conveyed it in geometric language opened the door for mathematical historians to “translate” geometrical texts into (pseudo-)algebraic texts.¹⁸ This approach put the spotlight on geometrical texts, as these were the most cryptic to the modern reader and therefore “most deserving” of the attention of historians of mathematics. The legacy of this approach to some extent remains today. Netz, in his chapter “Greek Mathematicians: A Group Picture”, acknowledges the existence of arithmetic texts, but chooses to ignore them in his description of Greek mathematicians.¹⁹ Asper, a few years after Netz, describes mathematics in ancient Greece as reflecting “two cultures”: the “practical” culture behind number manipulation and land measurement, and the “impractical” culture behind theorems and proofs concerning properties of numbers and figures.²⁰ These discussions, enormously influenced by the works of Plato and Aristotle, inevitably bring up that the “impractical” mathematicians are generally characteristic

¹⁸ Sabetai Unguru, “On the Need to Rewrite the History of Greek Mathematics,” *Archive for History of Exact Sciences* vol. 15, no. 1(1975): 69-76.

¹⁹ Reviel Netz, “Greek Mathematicians: A Group Picture,” in *Science and Mathematics in Ancient Greek Culture* (Oxford, New York: Oxford University Press, 2002), 204.

²⁰ Markus Asper, “The Two Cultures of Mathematics in Ancient Greece,” in *The Oxford Handbook of the History of Mathematics*, Oxford Handbooks (Oxford, New York: Oxford University Press, 2008), 108-120.

of wealthier classes, tying the study of theoretical math to elites, while simple arithmetic and land measurement are characteristic of the non-elite members of Greek society.²¹

In the words of Serafina Cuomo, “Asper’s picture is...sophisticated and, for several aspects, persuasive. Nonetheless, there are some threads left hanging.”²² Thinking of mathematics in terms of ratios (Greek λόγοι) rather than numbers may seem “impractical” from our modern standpoint, where much in the realm of so-called practical mathematics must be quantified with a real or at least rational number and given with precision. But it seems that precision was not forefront in the minds of many Greeks when measuring grain, for instance: Johnstone, in *A History of Trust in Ancient Greece*, argues using inscriptions and laws from classical Athens that many people rarely used measures for grain outside of retail and official contexts, instead estimating measurements by eye.²³ If practicality for a farmer was not based on precisely quantifying commodities with standardized measures, why should ways of thinking about the same commodities, albeit abstractly, be labelled automatically as “impractical” on the grounds that they do not involve numbers? It seems we may have crossed a line here which has clouded our view of how *ancients* judged mathematics’ utility. Therefore this method of investigation cannot be sufficient.

If we reject this first, easy path, this brings us to another option: trying to figure out how *ancient Greeks’* ideas map *into* our modern mathematics. As I mentioned above, going in this direction is much trickier. While the easy direction was a matter of subtraction, this way must be a matter of addition. To make matters even trickier, in ancient Greek there was no word directly corresponding to what modern English speakers call “mathematics”, so we cannot simply seek out “mathematics” in ancient Greece and add our findings to the list. The English word “mathematics” itself stems from the Greek μάθημα, which in turn comes from the verb μαθάνω, with basic meaning “to learn”. While this means that μάθημα could theoretically mean “anything learned”, some ancient sources do fix the term to specific subject areas. In his *Laws*, Plato seems to define three types of μαθήματα:

²¹ Cf. Netz, “Greek Mathematicians,” 201; Asper, “The Two Cultures,” 120-125.

²² Serafina Cuomo, “Mathematical traditions in Greece and Rome,” *HAU: Journal of Ethnographic Theory* 9, no. 1 (2019): 79.

²³ Steven Johnstone, *A History of Trust in Ancient Greece* (Chicago: University of Chicago Press, 2011), 35.

ἔτι δὴ τοίνυν τοῖς ἐλευθέροις ἔστιν τρία μαθήματα, λογισμοὶ μὲν καὶ τὰ περὶ ἀριθμοῦς ἐν μάθημα, μετρητικὴ δὲ μήκους καὶ ἐπιπέδου καὶ βάθους ὡς ἐν αὖ δεύτερον, τρίτον δὲ τῆς τῶν ἄστρον περιόδου πρὸς ἄλληλα ὡς πέφυκεν πορεύεσθαι.²⁴

Well now there are still three μαθήματα for free people: one μάθημα concerns calculations (λογισμοί) and things about quantities (ἀριθμοί), another one concerns measurement (μετρητικὴ) of length and plane and solid, and the third concerns the wanderings of the stars in relation to each other, how they go about by nature.²⁵

So Plato seems to limit μαθήματα to “free people” and defines them roughly as calculation and arithmetic, geometry, and astronomy. Indeed this interpretation of μαθήματα has shaped much of today’s scholarship on ancient Greek mathematics, including Netz and Asper in their works referenced above. But Plato of course wrote his works after the time of Old Comedy, so can we project Plato back onto those before him? It is certainly possible that Plato got this idea of μαθήματα from previous ideas, but we cannot confirm this without looking at sources before Plato. It is also worth noting that Plato discounts all enslaved people from learning these μαθήματα, yet clearly privately enslaved people had to have some basic knowledge of at least calculation, especially since they were often ordered to go to the agora to shop in place of their enslavers, let alone publicly enslaved people who were responsible for treasury management. Ismard even argues that “Xenophon...establishes a close connection between the status of slave and technical skill” through the myths of Daedalus.²⁶ The exclusion of enslaved people from grasping μαθήματα dictates that this definition cannot be sufficient.

So instead of entertaining either of the above routes, let us first ask: What are μαθήματα according to Old Comedy? The best place to look for an answer to this is Aristophanes’s *Clouds*, which includes the most instances of μανθάνω and its cognates (μάθημα, μαθητής [“learner”]).

²⁴ Plato, *Laws*, 817e-818a.

²⁵ Translation is my own.

²⁶ Paulin Ismard, *Democracy’s Slaves: A Political History of Ancient Greece* (Cambridge: Harvard University Press, 2017), 25.

Upon his arrival at the thought-shop (*phrontistērion*), Strepsiades talks to a μαθητής about what goes on inside and what is learned there. Their first conversation about Socrates tells us that μαθήματα relate to bugs, farts, and thievery, clearly a joke for the audience, but refers to observation of the moon in the process, which would appear to be a reference to astronomy.²⁷ When the door is finally opened, there is another joke about the learners’ butts learning how to do astronomy (ἀστρονομεῖν διδάσκεται),²⁸ before Strepsiades and the first learner examine a few instruments. These instruments are apparently in earnest for astronomy and geometry, referred to explicitly with the Greek words ἀστρονομία and γεωμετρία.²⁹ So from these first looks into the thought-shop, it seems that astronomy and geometry are genuine μαθήματα. Later in the play Socrates asks what Strepsiades wants to learn (μανθάνειν) about first, poetic measures (μέτρα), rhythms (ῥυθμοί), or words (ἔπεα), since he says Strepsiades has never been taught these before.³⁰ Perhaps the studies of these three concepts also counted as μαθήματα. One thing can be certain: common measures of volume are *not* related to μαθήματα. This is clear from the ensuing joke wherein Strepsiades mistakes the μέτρα, meaning poetic measures, for the homophonous μέτρα, meaning grain and other common volume measures, and is met with derision from Socrates, who calls him δυσμαθής (“bad at learning”, or perhaps “badly taught”).³¹ So from *Clouds* it would seem that μαθήματα are defined, at least, as astronomy, geometry, poetic measures, rhythms, and words, but explicitly not common measures.

But we would be remiss to accept the evidence from this one play as the only way to look at μαθήματα. So what are we to do? I suggest a compromise among the three discussions above, whereby “mathematics” can be seen through these components:

1. Attestations of μανθάνω and its cognates (μάθημα, μαθητής),
2. Attestations of λογισμός (“calculation”) and its cognate λογίζομαι (usually translated as “to calculate”),
3. Attestations of ἀριθμός (“number”) and its cognate ἀριθμέω (usually translated as “to count”),
4. Attestations and descriptions of astronomy (ἀστρονομία) and calendars,
5. Attestations and descriptions of geometry and land measurement (γεωμετρία),

²⁷ Aristophanes, *Clouds*, 135-183.

²⁸ *Ibid.*, 191-194.

²⁹ *Ibid.*, 200-202.

³⁰ *Ibid.*, 636-638.

³¹ *Ibid.*, 639-646.

6. Dealings with common measures (μέτρα), and
7. Dealings with money (χρήματα) and taxes (τέλεια).

The first uses the etymology of “mathematics”, the second and third are presumably foundational for Plato’s view of μαθήματα, the fourth and fifth seem common to all three discussions, the sixth is specifically excluded from μαθήματα in *Clouds*, and the last is a reasonable tangent from the second and third.³² Itemizing mathematics in this way avoids the pre-existing categorizations of practical vs. impractical and elite vs non-elite mathematics, and it provides concrete footprints to trace throughout the rest of Greek comedy. By no means do I claim that this itemization is exhaustive, nor that it is exactly how Greeks perceived mathematics. It is merely a starting point so that we can evaluate which elements appear, whether an Athenian audience member would classify those that appear as “mathematics” or μαθήματα, and how this informs our conception of popular ancient mathematics.

³² For the last, I am making a connection between “calculation,” “counting,” and the use of abaci in the realm of tax collection. This is attested in the fourth century BCE vase known as the Darius Vase, on which a tax collector is depicted working on an abacus, presumably calculating a tax.

2. Pre-Peace of Nikias Aristophanes

Of Aristophanes's plays, only eleven survive in full, although many others have come down to us in fragments only. In order to make the analysis of these plays more manageable, I have split Aristophanes's plays into those before the Peace of Nikias in 421 BCE and those after. This entirely artificial division puts five of the eleven full plays before the Peace of Nikias during either the Lenaia or Dionysia festival, and the remaining six full plays after the Peace of Nikias. On the other hand, four fragmentary plays survive from before the Peace of Nikias, while twenty-three survive from after. Therefore, the full plays are split almost evenly in this division, but the fragmentary plays fall more heavily on the post-Peace of Nikias side. The differences between the results of the two halves are few, and they will be pointed out in the next section. This section will discuss the portion of Aristophanes's surviving material from before the Peace of Nikias in relation to the mathematical items listed at the end of the first chapter. The works covered in this section, with their probable debut dates, are shown in the table below:

Comedy Title	Date ³³	Dionysia or Lenaia (if known)
<i>Babylonians</i>	426 BCE	Dionysia
<i>Acharnians</i> *	425 BCE	Lenaia
<i>Knights</i> *	424 BCE	Lenaia
<i>Farmers</i>	424 BCE	Dionysia
<i>Merchant Ships</i>	423 BCE	Lenaia
<i>Clouds</i> *	423 BCE	Dionysia
<i>Proagon</i> ³⁴	422 BCE	Lenaia
<i>Wasps</i> *	422 BCE	Lenaia
<i>Peace</i> *	421 BCE	Dionysia

Table 1: Pre-Peace of Nikias Comedies by Aristophanes (*Full Plays)

Within these works, as mentioned earlier, *Clouds* has the most attestations of $\mu\alpha\upsilon\theta\acute{\alpha}\nu\omega$ and its cognates, but forms of $\mu\alpha\upsilon\theta\acute{\alpha}\nu\omega$ specifically appear in four out of the five full plays. In

³³ These dates are taken from J. Henderson's introduction to the Loeb volumes of Aristophanes (1998).

³⁴ This play was produced by Philonides, but is widely attributed to Aristophanes.

Knights, it is used in reference to learning to play music and learning wrestling manoeuvres.³⁵ In *Wasps* and *Peace*, it is generally used in relation to understanding spoken words, with two exceptions. Once in *Wasps* it is used to mean “learn” with the infinitive γλωττοποιεῖν (“to work the tongue”) in a double-entendre,³⁶ and once in *Peace* it is used to mean the same thing with the activity of making handles for helmets, also part of a joke.³⁷ *Clouds* outshines all three of these works combined, as μανθάνω is used throughout the play both to mean “understand” and to mean “learn”, where jokes about learning are one of the main themes of the play. Μάθημα itself only appears once in *Clouds*, where it is used to refer to the education received from the thought-shop.³⁸ The noun μαθητής (“student”) also occurs only in *Clouds*. The last cognate of μάθημα I will include here, μαθητέον (“to be learned”) is quite rare throughout the whole of Greek literature, but in fact occurs once here, in *Wasps*:

B: οὐκ, ἢν ξυνηῖς γ' ἀνδράσι καλοῖς τε κάγαθοῖς,

ἢ γὰρ παρητήσαντο τὸν πεπονθότα,

ἢ λόγον ἔλεξας αὐτὸς ἀστεῖόν τινα,

Αἰσωπικὸν γέλοιοι ἢ Συβαριτικόν,

ὣν ἔμαθες ἐν τῷ συμποσίῳ· κᾶτ' ἐς γέλων

τὸ πρᾶγμ' ἔτρεψας, ὥστ' ἀφείς σ' ἀποίχεται.

Φ: μαθητέον γ' ἄρ' ἐστὶ πολλοὺς τῶν λόγων,

εἴπερ γ' ἀποτείσω μηδέν, ἢν τι δρῶ κακόν.³⁹

B: No, not if you hang around good and fine men. For either they would ask the inebriated one to leave, or you yourself would tell some wondrous story, a funny Aisops or Sybaris tale, which you learned (ἔμαθες) at a symposium. And then you would turn the situation to laughter, so that he goes off, leaving you alone.

P: Then I should learn (μαθητέον) a lot of those stories, if I am not going to pay for anything, when I do something bad.⁴⁰

³⁵ Aristophanes, *Knights*, 988-996 & 1238.

³⁶ Aristophanes, *Wasps*, 1280-1283.

³⁷ Aristophanes, *Peace*, 1258-1259.

³⁸ Aristophanes, *Clouds*, 1231.

³⁹ Aristophanes, *Wasps*, 1256-1263.

This instance of μαθητέον is certainly noteworthy, since the word is so rare in surviving Greek literature, and it is used shortly after a form of μανθάνω that might otherwise be thought of as simple comprehension.

What can we make of these attestations? Especially with the example with μαθητέον, many instances of μανθάνω and its cognates are closely tied with deception in these plays. The instances in *Wasps* and *Peace* which relate to learning a skill both refer to learning as a means to a different end than expected: in *Wasps*, learning to “work the tongue” is not for making speeches, which would add to the previous references to lyre-playing and acting in the same passage, but for pleasuring whores, while in *Peace* learning to make handles on helmets is not to make them more useful as tools of war or more aesthetically appealing, but to change their purpose entirely, namely to be drinking cups. In the second example here especially, learning to make handles amounts to learning how to sell something people otherwise would not need or even want to buy. The example with μαθητέον is explicitly about distracting people from whatever commotion arises, which would allow the character Philokleon to avoid consequences for his bad actions. This is all without even referencing *Clouds*, where Strepsiades, the play’s protagonist, tries to erase his debts by using the μάθημα of the thought-shop against his creditors (and succeeds in doing so).⁴¹ Immediately following the scene with the creditors, Phidippides, Strepsiades’s son, uses the μάθημα of the thought-shop to justify beating his parents.⁴² To further illustrate the deceptive nature of μανθάνω, in *Peace*, the god Hermes is the only one who can communicate with the statue of Peace, and after listening to her for the first time, he says “μανθάνω” before relaying her “complaints” to the others and the audience.⁴³ The statue of course cannot speak or give any indication that Hermes is relaying the correct information, so it is possible that Hermes is just relaying his own thoughts. Indeed Hermes says that Peace is angry because the Greeks kept turning her away, a sentiment he shared independent of Peace in his first encounter with Trygaios, the protagonist of this play, but in different words.⁴⁴ Discussions of *Clouds* have generally brought up the idea that learning, especially the learning associated with Sokrates’s crowd, was seen as frivolous and “wicked”, but from the above references we can see

⁴⁰ Translations are my own.

⁴¹ Aristophanes, *Clouds*, 1214-1302.

⁴² *Ibid.*, 1321-1451.

⁴³ Aristophanes, *Peace*, 658-667.

⁴⁴ *Ibid.*, 211-219.

that this negative view of learning extends beyond plays that attack the sophists and other learned folks directly.⁴⁵ Learning in pursuit of deception may even be a bit obscured in *Clouds*, since other plays display just this one aspect, whereas it is just one of many negative aspects of learning one can glean from *Clouds*.

Moving on from μανθάνω, there are no attestations of λογισμός in these plays at all, and the verb λογίζομαι is only attested five times. For four of these, the context is clearly related to numbers or measurement, whereas the remaining one seems unrelated to mathematics in any sense. In *Acharnians*, the protagonist Dikaiopolis says he is always the first to arrive to the *ekklēsia*, and while waiting there alone, among other things, he “reckons” (λογίζομαι).⁴⁶ Assuming this is related to the regular practice of doing quick math on a tablet (γραμματεῖον) during meetings, rather than merely pondering in the empty space, this is an example of the use of λογίζομαι in the context of calculation. In *Clouds*, Strepsiades also uses this verb when telling a slave to get him a tablet so he can tabulate the interest on his debts.⁴⁷ Λογίζομαι is also attested in a fragment of *Proagon*:

ὁ δ' ἀλφίτων < . . . > πριάμενος τρεῖς χοίνικας
κοτύλης δεούσας ἑκτέα λογίζεται.⁴⁸

The man who bought <...> three *choinikes* of barley ‘reckons’
(λογίζεται) a *hekteus* with a *kotulē* missing.

The complete context within the play is not entirely clear (Athenaeus uses this as evidence for the specific measure of grain known as a *kotulē*), but the inclusion of measurements confirms that this λογίζεται is mathematics-related. The last mathematics-related attestation of λογίζομαι is found in *Wasps*⁴⁹, when one of the protagonists, Bdelykleon, is trying to convince his father,

⁴⁵ Victor Ehrenberg, discussing *Birds* and *Clouds* in *The People of Aristophanes: A Sociology of Old Attic Comedy* (Oxford: Blackwell, 1943), writes: “To Aristophanes intellectual pursuits were as wicked a source of economic gain as politics.” (p. 45). See also Alan Hughes, *Performing Greek Comedy* (Cambridge: Cambridge University Press, 2012): “The most famous example of [comic attacks on citizens regarded as bad influences] is *Clouds*” (p. 26).

⁴⁶ Aristophanes, *Acharnians*, 28-36.

⁴⁷ Aristophanes, *Clouds*, 18-20.

⁴⁸ Athenaeus, *Learned Banqueters*, 11.478.

⁴⁹ This passage is discussed by Serafina Cuomo’s “Accounts, Numeracy and Democracy in Classical Athens” in *Writing Science: Medical and Mathematical Authorship in Ancient Greece*, and Ehrenberg’s *The People of Aristophanes*, pp. 39-40.

Philokleon, that jury service does not bring profit to jurors.⁵⁰ Other than these four attestations, λογίζομαι appears in *Knights*:

λοιδορῆσαι τοὺς πονηροὺς οὐδέν ἐστ’ ἐπίφθονον,
ἀλλὰ τιμὴ τοῖσι χρηστοῖς, ὅστις εὖ λογίζεται.⁵¹

It is not at all hateful to reproach the cowardly, but rather an honor for the best, whoever ‘reckons’ (λογίζεται) well.

But from this sentence and the context in which it appears, it is hard to find any connection between this λογίζεται and any kind of number or mathematical idea. Ἀριθμέω appears even fewer times, only twice throughout the works, and ἀριθμός appears only once. One instance of ἀριθμέω is in *Knights*, where it is used in a reproach of soldiers of the day for “counting up” (ἠρίθμησεν) how many soldiers they were about to fight before battle.⁵² The other is in *Wasps*, when Philokleon, trapped indoors by his son, wishes that Zeus would transform him into a stone “on which they count (ἀριθμοῦσιν) the shells”.⁵³ This stone and the shells refer to counting votes at the end of a trial and tallying up those in favor of the prosecution or the defendant. Ἀριθμός appears in *Clouds*, where Strepsiades reproaches the audience for their lack of education. Here, he calls the audience an ἀριθμός, among other things.⁵⁴

Before moving to the next topic, we must note that the employments of these two verbs and their cognates are noticeably different. Ἀριθμέω in *Knights* reproaches soldiers for thinking too much before going into battle: the implication is that the soldiers of old did not care who or how many they were fighting, they simply fought. The thinking involved in “counting up” the enemy came across as cowardice, and the rest of the current soldiers’ behavior reflected this as well. Along the same lines, the reference in *Wasps* implies an exact total: counting up votes is not a time for approximation. This reinforces Philokleon’s obsession with jury service, in that he wants to be part of the painstaking process of counting every individual vote. And finally the only instance of ἀριθμός is used reproachfully, as Strepsiades calls the audience stones, sheep

⁵⁰ Aristophanes, *Wasps*, 655-724.

⁵¹ Aristophanes, *Knights*, 1274-1275.

⁵² *Ibid.*, 565-573.

⁵³ Aristophanes, *Wasps*, 332-333.

⁵⁴ Aristophanes, *Clouds*, 1201-1203.

and a pile of amphorae in the same scathing list. These are contrasted with the use of λογίζομαι. In *Wasps*, Bdelykleon tells Philokleon:

καὶ πρῶτον μὲν λόγισαι φαύλως, μὴ ψήφοις ἀλλ' ἀπὸ χειρός,
τὸν φόρον ἡμῖν ἀπὸ τῶν πόλεων συλλήβδην τὸν προσιόντα...⁵⁵

And first simply ‘reckon’ (λόγισαι), not with counters but on your fingers, the tribute coming in to us collectively from the *poleis*...

Here, λόγισαι is explicitly supposed to be *simple* (φαύλως) and *on fingers* (ἀπὸ χειρός). This kind of tallying would never fly in a vote count: Bdelykleon is telling Philokleon not to think so much. The less cogitative nature of λογίζομαι lines up with its appearances in the other works as well. In the *ekklēsia*, one might not be able to listen intently to a meeting and do intense calculations at the same time, and considering that most of the other activities Dikaiopolis says he does before meetings are not cogitative (to say the least), there is little chance that Dikaiopolis would do anything as laborious as count up everything with counters. Similarly, Strepsiades wants to “reckon” (λογίσωμαι) his debts’ interest, but in his vocalization of whatever he is doing, he *never calculates the interest*, rather he merely lists the debts. Lastly, the fragment from the *Proagon* does not entail a precise calculation: it seems that whatever character this is is not carefully measuring grain, but rather making a quick estimation of the grain bought. Johnstone in *A History of Trust in Ancient Greece* argues that most grain measurement, especially outside the agora, may not have been precisely measured, sometimes even by sight,⁵⁶ and this would make the speed of the so-called calculation in the *Proagon* fragment even more apparent. Thus the difference between λογίζομαι and ἀριθμέω seems to be related to the amount of thinking involved in the action, with ἀριθμέω being the more cognitively taxing of the two.

A different side of mathematics, astronomy is only explicitly named in *Clouds*, but *Peace* touches on astronomical subjects of the day as well. References to astronomy seem to be regarding either observation of celestial bodies or the calendar, which was being refined by astronomers of the time. Observation appears twice in *Clouds* during the first conversation

⁵⁵ Aristophanes, *Wasps*, 656-657.

⁵⁶ Steven Johnstone, *A History of Trust in Ancient Greece* (Chicago: University of Chicago Press, 2011), 60.

between Strepsiades and the first learner: first the learner tells Strepsiades about Sokrates observing the moon and a lizard defecating into his agape mouth,⁵⁷ then he tells Strepsiades that the other learners' butts are looking up at the sky so that they can learn astronomy.⁵⁸ Turning to the calendar, the audience had to have been aware of the calendar's workings, since, while not quite a reference to the calendar or astronomy, *Acharnians* has a joke about a poor man named Lysistratos freezing and starving more than 30 days each month.⁵⁹ More directly, *Clouds* and *Peace* bring up frustration with the calendar being changed: the leader of the chorus of clouds says that the moon is unhappy with Athenians for messing around the days, with the result that the gods keep missing or anticipating dinners and festivals,⁶⁰ while in *Peace* Hermes throws the blame on the sun and moon for messing with the calendar.⁶¹ From both examples, it is clear that many must have been confused and frustrated with the calendar changes. Other than these references, one of the tools in the thought-shop in *Clouds* is apparently for astronomy, but the joke moves past it quickly.⁶²

The resulting picture of astronomy from these references is certainly negative. From the references to observation, astronomy is a foolish act that is little more than idle staring: Sokrates is observing the moon with mouth agape and is so oblivious that he does not notice the lizard above him, and astronomy can be performed by a person's butt. Frustration with the calendar, regardless of who is to blame, points to astronomy being somehow counter-productive to the general population, which may well have been the exact opposite of what astronomers thought of their own activities.⁶³ But one scene from *Peace* is not so clear:

O: ἴθι νυν, κάτειπέ μοι— **T:** τὸ τί;
O: ἄλλον τιν' εἶδες ἄνδρα κατὰ τὸν ἀέρα
 πλανώμενον πλὴν σαυτόν; **T:** οὐκ, εἰ μὴ γέ που
 ψυχὰς δὺ' ἢ τρεῖς διθυραμβοδιδασκάλων.
O: τί δ' ἔδρων; **T:** ξυνελέγοντ' ἀναβολὰς ποτόμεναι

⁵⁷ Aristophanes, *Clouds*, 170-174.

⁵⁸ *Ibid.*, 193-194.

⁵⁹ Aristophanes, *Acharnians*, 852-859.

⁶⁰ Aristophanes, *Clouds*, 607-626.

⁶¹ Aristophanes, *Peace*, 414-415.

⁶² Aristophanes, *Clouds*, 200-201.

⁶³ Robert Hannah, "Euctemon's *Parapēgma*" in *Science and Mathematics in Ancient Greek Culture* (Oxford: Oxford University Press, 2002), 129-131.

τὰς ἐνδιαεριαυρονηγέτους τινάς.

O: οὐκ ἦν ἄρ' οὐδ' ἄ λέγουσι, κατὰ τὸν ἀέρα
ὡς ἀστέρες γιγνόμεθ', ὅταν τις ἀποθάνῃ;

T: μάλιστα. **O:** καὶ τίς ἐστὶν ἀστήρ νῦν ἐκεῖ;

T: Ἴων ὁ Χῖος, ὅσπερ ἐποίησεν πάλαι
ἐνθάδε τὸν Ἀοῖόν ποθ'· ὡς δ' ἦλθ', εὐθεῶς
Ἀοῖον αὐτὸν πάντες ἐκάλουν ἀστέρα.

O: τίνες γάρ εἰς' οἱ διατρέχοντες ἀστέρες,
οἱ καόμενοι θέουσιν; **T:** ἀπὸ δείπνου τινὲς
τῶν πλουσίων οὔτοι βαδίζουσ' ἀστέρων
ἵπνους ἔχοντες, ἐν δὲ τοῖς ἵπνοῖσι πῦρ.⁶⁴

O: Come now, tell me—

T: What is it?

O: Did you see any other man than yourself wandering around
through the air?

T: No, except maybe those two or three dithyramb-producers' souls.

O: What were they doing?

T: They were flying about gathering some rambling odes floating in
the breeze.

O: Then it wasn't what they say, how we turn into stars up in the air
when someone dies?

T: Sure it was!

O: Then who is a star up there now?

T: Ion of Chios, the one who wrote *Morning* long ago here [on earth].
As soon as he got there, everyone called him the *morning* star.

O: So then who are the stars that dart across the sky, the ones that run
around on fire?

T: Those are some of the rich stars. They come home from dinner
with lanterns, and their lanterns are lit.

⁶⁴ Aristophanes, *Peace*, 826-841.

This passage is not directly referencing astronomy, but it does sound a bit like Trygaios is trying to explain heavenly phenomena in order to preserve the truth of “what they say”. This is then not astronomy by observation, but astronomy which ignores observation. After all Trygaios should have the answer to these questions, having been to the heavens and back, and indeed he made clear that he observed people’s souls wandering around there. Yet he decides to back-track on himself to maintain a status quo with some improvised explanations of stars’ behaviors. If astronomy is counter-productive to the general populace, why would Trygaios take on even a fake astronomer’s role? It seems there is some worth in explaining heavenly phenomena, but that worth is derived not from trying to find some new truth, but from finding evidence to support a folk explanation. So in a sense this passage is degrading to the “true” (as we might call them) astronomers under attack in the other references discussed above, but a need for heavenly explanations appears here uniquely.

Geometry and land measurement in general only come up once in all what survives of the plays of this section. Once inside Sokrates’s school and after passing the astronomy instrument, Strepsiades sees an instrument for doing geometry (γεωμετρία). After hearing that it is for measuring land, he assumes that it is for newly-colonized land. The learner then corrects him, telling him that it is actually for all land, to which Strepsiades responds that the concept is wondrous (ἀστεῖον).⁶⁵ Since Strepsiades laments his move away from the country in the beginning of the play, it does not seem coincidental that he would describe a concept with a word that blatantly derives from the word for town, almost as if this novel form of measurement is specific to “city folk”. And Strepsiades seems a bit baffled by the concept of measuring land that is already settled. Indeed owned land often had boundary markers that signaled that the land had already been measured.⁶⁶ Johnstone argues that actual appraisals of worth were quite rare in other disputes,⁶⁷ so it would be reasonable to imagine sending someone to measure land with geometer’s tools in a dispute would be similarly rare. So what benefit could there be in measuring “all land,” not just colonies’ land? The picture of geometry for Strepsiades is one of limited utility: geometry is useful, but not here. Nevertheless, while he might be initially

⁶⁵ Ibid., 202-205.

⁶⁶ Johnstone, *A History of Trust*, 94.

⁶⁷ Ibid., 86-88, 93-95.

confused, Strepsiades is open to the possibility of measuring all land, and even concludes that the instrument is in fact useful (χρήσιμον).

Taxes and/or money feature broadly throughout every full play, but analogies where something is compared to an obol, implying worthlessness, may not necessarily reflect “mathematics”. Since tax collection presumably involved a significant amount of number manipulation, the focus of this discussion will be money in relation to tax collection and the role of tax collector itself. In the earliest of the plays, *Acharnians*, Dikaiopolis withdraws to the countryside and barter with traveling merchants as they come by. One of these merchants, a Theban, has a variety of foodstuffs and animals for sale, and offers up an eel to Dikaiopolis. Dikaiopolis then takes this eel as an “agora tax” (ἀγορᾶς τέλος).⁶⁸ Since many taxes were ostensibly paid using coins,⁶⁹ this is a very peculiar tax, for which Dikaiopolis is the tax collector. *Knights*, however, is the play where tax collection really stands out: recurrently, the main antagonist, Paphlagon, is tied to taxes and their levying. The chorus leader calls him a tax collector (τελώνης) explicitly,⁷⁰ and later the chorus says that the taxes (τέλη) are full of his rashness (θράσος).⁷¹ In the latter half of the play, Paphlagon himself threatens to put the protagonist, the sausage seller, down in the public register (ἐγγραφή) as rich so that he is burdened with war taxes (εἰσφοράς).⁷² While these references do not refer specifically to the manipulation of quantities or counting up money, they paint a picture of people whose job that was. In addition to these plays, there is of course the reference to taxes and tribute in the calculation in *Wasps*, mentioned earlier in the discussion of λογίζομαι.

Once again this picture is mostly negative. Paphlagon is widely regarded as a stand-in for the contemporary politician Kleon, which is why Paphlagon is portrayed negatively in a number of ways. But the choice to portray him as a manipulative tax collector, who made a lot of money in the *boulē*⁷³ and pocketed money elsewhere,⁷⁴ must underlie a larger distrust of tax collectors.

⁶⁸ Aristophanes, *Acharnians*, 860-896.

⁶⁹ This is evident from the calculation in *Wasps* mentioned above, where Bdelykleon adds up, among other things, the τέλη in lines 655-663. Many inscriptions also show evidence of taxes paid in coinage. See also Johnstone, *A History of Trust*, pp. 9-10 and 54-55, and Fawcett, “‘When I Squeeze You with *Eisphorai*’: Taxes and Tax Policy in Classical Athens,” *Hesperia: The Journal of the American School of Classical Studies at Athens* 85, no. 1 (January-March 2016): 177.

⁷⁰ Aristophanes, *Knights*, 248.

⁷¹ *Ibid.*, 304-312.

⁷² *Ibid.*, 923-926.

⁷³ *Ibid.*, 773-776.

⁷⁴ *Ibid.*, 438.

This would tie into the “agora tax” in *Acharnians*: the tax collector, Dikaiopolis, demands a share of the *goods*, rather than money for the state. While coinage has notably disappeared from Dikaiopolis’s reclusion at this point,⁷⁵ apparently tax customs have not, and quite an unfair one at that. *Knights* shows that tax collection is a very political activity, deeply tied to corrupt politicians like Kleon: the wealth of those who handle the taxes shows that those who collect them are collecting too much and those who get what the collectors do not keep are keeping the rest. *Wasps* provides the same picture, as argued by Cuomo, that “politically, things do not really add up”, and officials are pocketing money somewhere along the way from citizen to treasury.⁷⁶ The Attic privatization of tax collection, made possible by selling the right to collect tax, certainly incentivizes exacting higher taxes,⁷⁷ so this image of tax collection is predictable, but confirmed through these references.

The last component, that of common measures, is seen in many of the plays and figured into the above discussion of λογίζομαι. When Sokrates asks Strepsiades in *Clouds* which is better, trimeters or tetrameters, Strepsiades responds not with a rhythmic measure (μέτρον), but with a measure of volume, namely the *hēmiekteus* (ἡμιέκτευς), which is equivalent to four *choinikes* (χοίνικες).⁷⁸ Strepsiades, originally a farmer from the country, cares not about poetics, but rather the measures of grain. Interestingly, in *Acharnians*, wherein Dikaiopolis longs to live in the country,⁷⁹ once he is set up by himself there with his independent peace-treaty, he no longer trades with money, but still trades in *choinikes* with the Megarian,⁸⁰ thus again pointing to rural use of these common measurements, or at least vessels of the same name. Moreover, in *Peace* when Trygaios is living his peaceful life in the country: a weapon-seller tries to sell him two helmets, and Trygaios’s offer is three *choinikes* of figs, not money.⁸¹ Johnstone argues that standardized measures like these were rarely used outside of official and marketplace business,⁸² and these three plays show imprecise measurements alive and well outside the *polis*. These

⁷⁵ In each transaction Dikaiopolis makes with traveling merchants, goods are exchanged for other goods: he trades garlic and salt for two “pigs” from the Megarian (812-815) and a sycophant for the Theban’s wares (898-907). Dikaiopolis then rejects a deal with Lamachos, who tries to use drachmas to buy food from him (960-970), and later says he would not pour out any peace (wine) for 1,000 drachmas (1051-1055).

⁷⁶ Cuomo, “Accounts, Numeracy and Democracy in Classical Athens” in *Writing Science: Medical and Mathematical Authorship in Ancient Greece* (Berlin: De Gruyter, 2013), 272-273.

⁷⁷ See Johnstone, *A History of Trust*, p. 90.

⁷⁸ Aristophanes, *Clouds*, 641-644.

⁷⁹ Aristophanes, *Acharnians*, 32-33.

⁸⁰ *Ibid.*, 811-814.

⁸¹ Aristophanes, *Peace*, 1214-1223.

⁸² Johnstone, *A History of Trust*, 35-61.

measures certainly were not the standardized measures used in the *polis*, and this is shown in *Clouds*: Strepsiades uses the *chous* (χοῦς) to describe the fat belly of the first creditor, saying that it could hold six *choes*.⁸³ The visual nature, not the precise nature, of these measurements shines from this detail, especially if the actor's stomach was not padded to look fat.⁸⁴

The explicit verb for “to measure” (μετρέω) appears four times in these plays, twice in *Acharnians*, once in *Knights*, and once in *Peace*. Dikaiopolis mentions measuring out food rations (σιτίων μετρούμενων) for troops during a tirade against Athenians who are too eager to go to war for breaking import laws,⁸⁵ and later refuses to measure out (μέτρησον) any peace-wine for a man whose eyes hurt from crying over lost oxen.⁸⁶ In *Knights* the sausage seller has oracle prophecies about people who “measure (μετρούντων) grain in the agora badly”, which could entail what fates await such people or who such people are, so as to avoid them.⁸⁷ Lastly, just after telling the weapons-dealer to turn his helmet into a balance, Trygaios tells him that the helmets would sell well with the Egyptians for measuring out (μετρεῖν) purgatives.⁸⁸ In a rare reference to measuring weight rather than volume, Trygaios tells the weapons-dealer to turn his helmet into a scale and use it to weigh (ιστάναί) figs for the enslaved people in the fields.⁸⁹ It is not clear why figs would be weighed instead of measured by volume, but it would appear to be a more painstaking process. The joke would then be at the expense of the enslaved people in the fields, on the assumption that they were not worthy of such accuracy and meticulousness.

These various references point to one definite result: that common measures were significant outside of the agora (not necessarily that they were *used*, however). *Choinikes* seem quite prominent in the minds of those living outside the urban area of Athens, from the references above. In fact, in *Wasps* Philokleon says that he taught barbarians to cry “four to the *choinix*”, a reference to the fact that one *choinix* held four *kotulai*,⁹⁰ which makes *choinikes* sound uniquely Greek, despite the obvious humor. It is possible that some of these measures

⁸³ Aristophanes, *Clouds*, 1237-1238.

⁸⁴ Hughes, *Performing Greek Comedy*: “When we first see [the undercostume] on a fragment of an Attic cup dated c. 430 [BCE], the fleshings and torso are clearly delineated, but the stomach is not padded; indeed, only two scenes painted before 410 show the padding which had become ubiquitous when the first comic figurines were made, about a decade later” (190).

⁸⁵ Aristophanes, *Acharnians*, 541-555.

⁸⁶ *Ibid.*, 1018-1036.

⁸⁷ Aristophanes, *Knights*, 1007-1010.

⁸⁸ Aristophanes, *Peace*, 1252-1254.

⁸⁹ *Ibid.*, 1245-1249.

⁹⁰ Aristophanes, *Wasps*, 438-440.

were viewed as just part of being “Greek,” which would explain why they remain prominent for Greeks when they remove themselves from urban life. Considering the presence of Greek-speaking foreigners at the Dionysian festival, it would seem that much of the Greek-speaking world would have to know what these measures are in order to continue coming to see plays that constantly reference them, even if they used a measure for something different than the Athenians (see Section 6).

On the other hand, the act of measuring itself does not seem to extend beyond official duties and the market-place, at least in Athens, as has already been argued by Johnstone. Of the instances of μετρέω, one is in a military context (i.e. an official duty), one is in the agora, one is in Egypt, and the remaining one in the country. But this last one is not carried out, as Dikaiopolis scorns the request, saying that he does not do public service (οὐ δημοσιεύων).⁹¹ Referencing Egypt specifically in *Peace* may have special significance due to the potential presence of Egyptians in the audience, since *Peace* was performed at the Dionysia, but the common measures mentioned in these plays seem to have had a degree of Greekness to them. In any event, actual precise measurement is portrayed as absurd for the Greek farmer outside the agora and military service.

⁹¹ Aristophanes, *Acharnians*, 1030.

3. Post-Peace of Nikias Aristophanes

This section will deal with references to mathematics in the remaining plays and fragments of Aristophanes which were produced after the Peace of Nikias in 421 BCE. The plays covered in this section can be found in the table below with their prospective dates:

Comedy Title	Date ⁹²
<i>Seasons</i>	421-412 BCE
<i>Women Claiming Tent Sites</i>	After 420 BCE
<i>Anagyrus</i>	419-417 BCE
<i>Polyidus</i>	After 415 BCE
<i>Amphiaraus</i>	Lenaia of 414 BCE
<i>Birds*</i>	Dionysia of 414 BCE
<i>Heroes</i>	413-411 BCE
<i>Daedalus</i>	413-406 BCE
<i>Peace II</i>	After 412 BCE
<i>Lysistrata*</i>	Lenaia of 411 BCE
<i>Thesmophoriazousai I*</i>	Dionysia of 411 BCE
<i>Triphales</i>	410-409 BCE
<i>Thesmophoriazousai II</i>	410-405 BCE
<i>Lemnian Women</i>	After 410 BCE
<i>Old Age</i>	After 409 BCE
<i>Phoenician Women</i>	After 409 BCE
<i>Wealth I</i>	408 BCE
<i>Gerytades</i>	Around 408 BCE
<i>Dramas or Centaur</i>	Before 406 BCE
<i>Frogs*</i>	Lenaia of 405 BCE
<i>Telemessians</i>	Around 402 BCE
<i>Fry Cooks</i>	Before 400 BCE
<i>Aeolosicon I</i>	Before 395 BCE

⁹² These dates are taken from J. Henderson's introduction to the Loeb volumes of Aristophanes (1998).

<i>Storks</i>	398-389 BCE
<i>Ekklesiazousai</i> *	Around 392 BCE
<i>Wealth II</i> *	388 BCE
<i>Aeolosicon II</i>	387 BCE
<i>Cocalus</i>	Dionysia of 387 BCE
<i>Danaids</i>	Date Uncertain

Table 2: Post-Peace of Nicias Comedies by Aristophanes (*Full Plays)

Of these, *Birds*, *Lysistrata*, *Thesmophoriazousai I* (from here on referred simply as *Thesmophoriazousai*), *Frogs*, *Ekklesiazousai*, and *Wealth II* (from here on referred simply as *Wealth*) survive in full, while the rest only survive as fragments. It is worth noting that references to mathematics, according to the criteria detailed earlier, in this period are remarkably scarcer than in the plays before the Peace of Nicias, despite the fact that we have more physically surviving text from this period. Additionally, most of the references occur in *Birds* and *Frogs*, with only a few outside these two works.

Cognates of the verb *μανθάνω* appear in all six fully extant plays, but none of the fragments. Their uses here seem to gravitate towards two English concepts: “understanding”, in reference to spoken words, and “learning”, both in the sense of obtaining new information and that of connecting old and new information. *Frogs* makes the most use of the “understanding” *μανθάνω*, sometimes as sign that the actor’s character has understood instructions given to them (e.g. in lines 194-195, Xanthias is given instructions for where to await Charon’s boat on the other side of the river, and he confirms that he understands with *μανθάνω*). The second usage corresponding to “learning” appears more often (9 definite instances of the first usage versus 23 definite instances of the second) and includes all instances of compounds of the verb (*ἐκμανθάνω*, *προσμανθάνω*, and *μεταμανθάνω*). When examining this side of *μανθάνω*, we find that the only instance of *μάθημα* in these works is associated with learning in *Birds*, where the hoopoe talks about learning from enemies, and the *μάθημα* of building ships and walls can keep cities safe.⁹³ Furthermore, the only instance of *μαθητής* appears in *Frogs*, when Euripides (the character, based on the tragedian) refers to his own followers and those of Aeschylus as *μαθητοί*.⁹⁴ This may appear to fall under the first usage, but at the beginning of *Thesmophoriazousai*, Euripides

⁹³ Aristophanes, *Birds*, 375-380.

⁹⁴ Aristophanes, *Frogs*, 964.

says to Mnesilochos πόλλ' ἄν μάθοις τοιαῦτα παρ' ἐμοῦ (“you could learn [μάθοις] many things like this from me”) after teaching him why eyes and ears have the shapes they do;⁹⁵ thus Euripides is portrayed as someone who could have true μαθητοί, just like Socrates in *Clouds*, and suggests the instance in *Frogs* could and should be taken as such. However, a strict dichotomy between “understanding” and “learning” is obfuscated by two instances where verb forms of μανθάνω are paired with rarer cognates in quick succession. Both instances occur in *Frogs*: the first is a famous passage which is used to show the literacy of the audience of comedy:

εἰ δὲ τοῦτο καταφοβεῖσθον,
 μή τις ἀμαθία προσῆ
 τοῖς θεωμένοισιν, ὡς τὰ
 λεπτὰ μὴ γνῶναι λεγόντων,
 μηδὲν ὀρρωδεῖτε τοῦθ'· ὡς
 οὐκέθ' οὔτω ταῦτ' ἔχει.
 ἐστρατευμένοι γάρ εἰσι,
 βιβλίον τ' ἔχων ἕκαστος
 μανθάνει τὰ δεξιά.⁹⁶

If you two [sc. Euripides and Aeschylus] have this great fear, that some stupidity [ἀμαθία] is here among the spectators, so they miss the subtleties when you speak, don't fear this at all; as it's not like that anymore. They've been drawn into line, and each has a scroll and understands [μανθάνει] the clever things.

The second comes towards the end of the play, appearing in one of what Henderson calls “authorial variants”:⁹⁷

E: ἐγὼ μὲν οἶδα καὶ θέλω φράζειν.

⁹⁵ Aristophanes, *Thesmophoriazousai*, 13-22. Translations are my own.

⁹⁶ Aristophanes, *Frogs*, 1108-1114.

⁹⁷ Jeffrey Henderson, *Aristophanes IV: Loeb Classical Library 180* (Cambridge, MA: Harvard University Press, 2002), 221 n. 140.

Δ: λέγε.

Ε: ὅταν τὰ νῦν ἄπιστα πίσθ' ἠγώμεθα,
τὰ δ' ὄντα πίστ' ἄπιστα—

Δ: πῶς; οὐ μανθάνω.
ἀμαθέστερόν πως εἶπε καὶ σαφέστερον.⁹⁸

E: I know and want to point something out.

D: Speak.

E: When we deem currently untrustworthy things trustworthy, truly trustworthy things untrustworthy be—

D: What? I don't understand [μανθάνω]. Talk a bit less smart [ἀμαθέστερόν] and a bit clearer.

In each example, the verb form (μανθάνει, μανθάνω) corresponds to the “understanding” usage, while the cognate (ἀμαθία, ἀμαθέστερόν) is more coherently taken as from the “learning” usage. Paired so closely like this, the line between the two usages seems a bit blurred, and it calls attention to the artificiality of making this distinction based on how μανθάνω translates into idiomatic English. It is more likely that the two usages were not distinguished as such by the Greek speaker, and it may be more insightful to compare the use of μανθάνω to other verbs of knowing and understanding (e.g. οἶδα, γινώσκω, etc.). In considering the specified objects of μανθάνω in these works, we find a variety of things that can be “learned”. In *Birds* one can learn songs⁹⁹ and behaviors,¹⁰⁰ in *Ekklesiazousai* one can learn arguments,¹⁰¹ in *Frogs* one can learn dances,¹⁰² and in *Wealth* one can learn a skill or craft.¹⁰³

Putting μανθάνω aside, let us examine the instances of λογίζομαι and its cognates. This verb appears only three times, and λογισμός does not appear at all. At the beginning of *Lysistrata*, the title character Lysistrata was expecting and ἐλογιζόμεν that the Achaean women would show

⁹⁸ Aristophanes, *Frogs*, 1442-1445.

⁹⁹ Aristophanes, *Birds*, 936-939.

¹⁰⁰ *Ibid.*, 1362-1364.

¹⁰¹ Aristophanes, *Ekklesiazousai*, 241-244.

¹⁰² Aristophanes, *Frogs*, 152-153.

¹⁰³ Aristophanes, *Wealth*, 905.

up first;¹⁰⁴ in *Frogs*, Dionysos says he will count (λογιοῦμαι) with counters (ψήφοι) how many times Euripides points out the same line across Aeschylus's plays;¹⁰⁵ and finally in *Wealth* the main antagonist, Chremylos, thinks that another character, Blepsidemus, would manipulate the number of minas he spent bribing politicians for him (καὶ μὴν φίλως γ' ἄν μοι δοκεῖς, νῆ τοὺς θεοῦς, / τρεῖς μνᾶς ἀναλώσας λογίσασθαι δώδεκα, "And yet, it seems to me, by the gods, that you would gladly reckon [λογίσασθαι] 12 minas even though you spent three").¹⁰⁶ The connections with actual number manipulation in these three examples are quite different. When Lysistrata uses the verb, it does not seem obvious that she has numbers in mind. To stretch the point, she could be thinking of the number of women needed to get her conspiracy off the ground, and perhaps she was expecting that the plan would bring a better turnout from Achaean women than from others. Dionysos, however, is explicitly counting the occurrences in the lines that follow his use of λογίζομαι, so he is certainly connecting λογίζομαι and numbers. Lastly, deceitful manipulation of numbers, rather than counting, is on Chremylos's mind when he uses λογίζομαι. If we take these three instances and try to find a common thread, the result is that λογίζομαι in each context is related to not just numbers, but the information demonstrated by those numbers or manipulations thereof. If Lysistrata is "counting" on the Achaeans to turn out in droves, the great number of women would give an indication about how likely her plan is to succeed. By counting the occurrences not just mentally, but with counters, Dionysos creates a physical representation of how repetitive Euripides says Aeschylus is, and the more times the line occurs, the larger the visualization created by the counters could become.¹⁰⁷ Eventually, the size of the pile or the length of the line will speak for itself, independent of the exact number of counters it contains. And Chremylos is concerned by the manipulation of three into twelve, because that would be an intentional and arbitrary falsification, not just a normal recording of expenses; he has no way of knowing what outlandish price Blepsidemus would charge him and what his reasoning would be. Each of these uses seems to go beyond calculation and suggests that λογίζομαι concerns more than just a numerical aspect. In addition to these instances of λογίζομαι, a fragment of *Cocalus* (fr. 362) has someone bring out a ψηφολογίον (account-board)

¹⁰⁴ Aristophanes, *Lysistrata* 61-63.

¹⁰⁵ Aristophanes, *Frogs* 1263.

¹⁰⁶ Aristophanes, *Wealth* 380-381.

¹⁰⁷ This is assuming he was not counting with the counters as if with an abacus. However, even with an abacus, the visualization would show a large number from the position of the counters on the abacus. For more information on abacus use in ancient Greece, see Alain Schärfling, *Compter avec des cailloux* (Lausanne: Presses polytechniques et universitaires romandes, 2001), 285-321.

and two stools. Little can be made of this, especially without more context, but it is interesting to note the shared root λογ- found in this word, the implied collaboration of two people at the board, and the survival of this rare word in a fragment of an otherwise lost play.

In what survives of these works, ἀριθμέω does not appear and ἀριθμός is attested only in *Birds* in line 1251. This scene has the main protagonist, Peisthetairos, threaten the goddess Iris for passing through the newly-founded city of birds:

ἄκουον αὐτή· παῦε τῶν παφλασμάτων·
ἔχ' ἀτρέμα. φέρ' ἴδω, πότερα Λυδὸν ἢ Φρύγα
ταυτί λέγουσα μορμολύττεσθαι δοκεῖς;
ἄρ' οἴσθ' ὅτι Ζεὺς εἴ με λυπήσει πέρα,
μέλαθρα μὲν αὐτοῦ καὶ δόμους Ἀμφίονος
καταιθαλώσω πυρφόροισιν αἰετοῖς;
πέμψω δὲ πορφυρίωνας ἐς τὸν οὐρανὸν
ὄρνεις ἐπ' αὐτὸν παρδαλᾶς ἐνημμενους
πλεῖν ἑξακοσίους τὸν ἀριθμόν.¹⁰⁸

Listen here. Stop rustling. Keep still. Come on now, you think you'll frighten a Lydian or a Phrygian saying that stuff? Do you know that if Zeus keeps annoying me, I'll burn his Amphion's roof and walls to the ground with fire-eagles? And I'll send swampghens into the heavens to him, birds clad in leopard, more than 600 in number [τὸν ἀριθμόν].

The inclusion of the number of birds in the swampghen brigade seems to be for added intimidation: if we take πορφυρίωνας to mean the modern-day “swampghen”, they are not the most graceful flyers (likely even less so when wearing leopard skins), but their screeching bird-calls can sound quite terrifying. 600 such bird-calls would be all the more frightening.¹⁰⁹ But the distinction between this ἀριθμός and the earlier λογίζομαι is the lack of action. Ἀριθμός may not

¹⁰⁸ Aristophanes, *Birds*, 1243-1251.

¹⁰⁹ Whether Zeus would actually be frightened by 600 clumsy birds the size of a chicken is not clear to me.

be a verb, but upon hearing the number the listener does not need much thought to imagine the increase in terror 600 birds would bring over just one. Each λογίζομαι is performative, where information about the action is given both by the performance of the action and the result of it, but this ἀριθμός is set up to be an instant bit of information, shaped by the two adjectives that precede it.

References to astronomy, geometry, taxes, and measurement are scarce, aside from the episode with Meton which will be dealt with last. No attestations of ἀστρονομία, ἀστρονομεῖν, γεωμετρία, τέλος, or τελώνης are preserved. Widening the net of astronomy gives two attestations of μετέωρος (both in *Birds*) and three of ἀστήρ (one in *Birds*, one in *Ekklesiazousai*, and one in *Frogs*). Of these, the only one that provides some interest is the reference to μετέωρος in *Birds* at line 690, where the birds say that humans could learn correctly everything about τῶν μετεώρων from the birds. The others reference the time of day,¹¹⁰ a coincidental planet,¹¹¹ how the birds should name their city,¹¹² and one in the Meton episode.¹¹³ The verb γεωμετρῆν appears only in the Meton episode. Taxation is only referenced tangentially through reference to management of the treasury (via ταμίας and ταμιεύω). These words occur in *Birds*, *Lysistrata*, *Thesmophoriazousai*, and *Ekklesiazousai*, and all reference treasury-management being performed by women. In *Birds* the woman or goddess Prometheus tells Peisthetairos to get from the heavens is the one who manages the treasury of the heavens.¹¹⁴ The other three plays all feature women claiming positions of power, and each play references how women would be better than men at managing the treasury because of their experience being ταμίαι at home¹¹⁵ or because they have done it in the past.¹¹⁶ While this could be a repeated joke whenever women appear on stage, the inclusion of the woman treasurer of the heavens in *Birds* does not seem to fit into this explanation.

Of these four topics, measurement gets the most representation (ignoring for the moment the significance of the named astronomer Meton). Measurement words such as κοτύλη and μέδιμνος appear both in plays and in fragments, but many are of little interest. Two specific instances of κοτύλη are brought up in relation to market swindling, also using the same words for

¹¹⁰ Aristophanes, *Ekklesiazousai*, 83.

¹¹¹ Aristophanes, *Frogs*, 340-345.

¹¹² Aristophanes, *Birds*, 818.

¹¹³ *Ibid.*, 1007.

¹¹⁴ *Ibid.*, 1537-1545.

¹¹⁵ Aristophanes, *Ekklesiazousai*, 211-212; *Lysistrata*, 488-497.

¹¹⁶ Aristophanes, *Thesmophoriazousai*, 418-421.

swindle (διαλυμαίνεται) and the retailer (καπηλίας) in both lines. One occurs in *Wealth*,¹¹⁷ while the other slightly more interesting reference is in *Thesmophoriazousai*.¹¹⁸ In this second reference the κοτύλη is explicitly referred to as a νόμισμα (“standard”), implying that one source of swindling is using a κοτύλη that does not measure up. Therefore while many people may not have had a true standard κοτύλη as we may think of a standard measure today, there was a popular notion of how much a κοτύλη *should* be. The actual verb μετρέω occurs only in *Birds* three times. Demeter is said to “measure out” (μετρείτω) grain for hungry birds,¹¹⁹ Meton measures (μετρήσω) the air with various instruments,¹²⁰ and when the wall around the city is complete a bird-messenger reports that he measured (ἐμέτρησα) the height to be “one hundred fathoms” (ἑκατοντορόγυιον).¹²¹ The first seems to play on public grain supplies, while the last two seem to be futile measurements: Meton explicitly “land-measures the air” (γεωμετρήσαι...τὸν ἀέρα), and measuring the height of a wall meant to keep out others who are capable of flight seems trivial. Lastly, μέτρον and σταθμός occur in the same line in *Birds*, while σταθμός appears on its own in *Frogs* as well. The only attestation of μέτρον occurs shortly after the episode with Meton; the Decree-Seller gives a sample decree stating that the bird city will use the same measures (μέτροισι), weights (σταθμοῖσι), and standards (νομίσμασι) as the Olophyxians,¹²² playing on a pun with the word for “lamenters” (ὀτοτύξιοι) found later.¹²³ Interestingly, *Frogs* contains an extended passage about weighing the words of Euripides and Aeschylus using a balance (σταθμός).¹²⁴ However, we must note that the weighing done here is comparative, not for the purpose of quantification: Dionysos is only interested in *whose are heavier*, not *how heavy the words are*.

We now have examined each of the references to mathematics in what remains of Aristophanes. To ensure that we are not extrapolating from a flawed sample of examples, we will have to examine the fragments of other authors of Old Comedy. But first, let us take a closer

¹¹⁷ Aristophanes, *Wealth*, 435-436.

¹¹⁸ Aristophanes, *Thesmophoriazousai*, 346-347.

¹¹⁹ Aristophanes, *Birds*, 580.

¹²⁰ *Ibid.*, 1004.

¹²¹ *Ibid.*, 1130-1131.

¹²² *Ibid.*, 1040-1041.

¹²³ Benjamin Bickley Rogers, *Aristophanes II: Loeb Classical Library 179* (Cambridge, MA: Harvard University Press, 1989), 231 n. e.

¹²⁴ Aristophanes, *Frogs*, 1365-1410.

look at the scene mentioned above with the only named potential mathematician in Aristophanes:
Meton in *Birds*.

4. Meton in *Birds*

In Aristophanes's *Birds*, there is a scene where five individuals of different professions attempt to swindle Peisthetairos just after the priest has finished the founding sacrifice. Each approaches Peisthetairos peddling a skill that they deem essential for a newly-founded city (Peisthetairos, of course, deems otherwise): the first a poet, the second an oracle-dealer, the third an individual named Meton, the fourth an inspector from Athens, and the fifth a decree-dealer. It should already be apparent that the third individual, Meton, is the only peddler given a name; all the others respond to the question "Who are you?" with an occupation. The reason this is significant to this study is that Meton is known to have been an extraordinary astronomer and mathematician: one of his most renowned contributions to ancient Athenian society was the "Metonic" 19-year calendar cycle,¹²⁵ which aimed to minimize the calendrical drift caused by the complications of trying to collate lunar and solar calendars. Therefore this is a very rare instance, and in fact the only in Aristophanes, of a named potential mathematician appearing in comedy, and it warrants special attention.

This is not the first time a scholar has noted the peculiarity of this appearance. Scholarship about this episode stretches back to the 19th century. In 1937, Wycherley attempted to piece together a geometric diagram from Meton's description of his actions with the instruments he has on stage.¹²⁶ In this article Wycherley claims that "Aristophanes' primary object is to poke fun at Meton; since Meton is a mathematician and since a city is in building, the most appropriate thing he can do is to draw a geometrical figure."¹²⁷ Wycherley is cited by most of the scholars that follow him in their discussions about Meton in *Birds*. In 1943, Ehrenberg attributes Meton's appearance to "the same attitude of mind in the poet which made him depict Sokrates as a mere sophist",¹²⁸ also calling Meton a mathematician, but he says he appears as "a town-planning architect".¹²⁹ In a 1971 work on orthogonal town planning, Castagnoli relates that some believe that Meton's appearance actually refers to the renowned town planner Hippodamus of Miletus, as the plan laid out by Meton in the scene resembles "Oriental" town configurations,

¹²⁵ Although this intercalation figuration was already known by the Babylonians, and it is possible that Meton merely echoed this knowledge to the Greeks. See Robert Hannah, *Greek & Roman Calendars: Constructions of Time in the Classical World* (London: Gerald Duckworth & Co., 2005), 52-58.

¹²⁶ R. E. Wycherley, "Aristophanes, *Birds*, 995-1009," *The Classical Quarterly* 31, no. 1 (1937), 22.

¹²⁷ *Ibid.*, 31.

¹²⁸ Victor Ehrenberg, *The People of Aristophanes* (Oxford: Blackwell, 1943), 45.

¹²⁹ *Ibid.*, 44.

which Hippodamus may have spread to the Greek world.¹³⁰ MacDowell in 1995 claims that Meton again is a mathematician and raises the idea that Meton is a named representation of *the* mathematician, just as Socrates represents *the* sophist in *Clouds*,¹³¹ which is a step beyond Ehrenberg's interpretation of the scene. Entering the 21st century, Hannah focuses mostly on Meton's astronomical contributions, but in mentioning this scene he says he is depicted as a geometer or town-planner.¹³² Finally most recently in 2010, Amati revisits Wycherley's geometric diagram and argues that the resulting town plan does not fit with the theme of the play as a whole, which rejects the established Athenian norms for communal life, favoring instead a more isolationist, tyrannical society.¹³³ Here Amati cites both Wycherley and MacDowell, but says explicitly that the real Meton was *not* a geometer nor a city-planner, but an astronomer and "calendar plotter".¹³⁴ It seems worth noting that of these six authors, only Wycherley and Amati were writing works devoted to the scene, whereas the other four authors merely mention the scene within larger overviews of comedy or, in the case of Hannah, of calendar systems.

But what seems to vary most wildly in these authors is Meton's *essential identity*. Wycherley does identify Meton as a "mathematician, astronomer and engineer", but seems to focus on his identity as mathematician throughout.¹³⁵ Ehrenberg and MacDowell all exclusively identify the real Meton as a mathematician, although Ehrenberg differentiates the real Meton from his representation in *Birds* ("a town-planning architect"). MacDowell extrapolates from this scene onto the real Meton, proposing that Meton dabbled in town-planning despite no other evidence for such a claim.¹³⁶ Meanwhile, Castagnoli and Hannah seem to identify Meton as a sort of town-planner in this scene, although Hannah asserts further that the real Meton was an astronomer, rather than a mathematician. It is not until Amati that someone explicitly excludes the real Meton from certain identities. So who was Meton? Was he a mathematician? Was he an astronomer? Did he really dabble in town-planning? Maybe a combination of the three?

¹³⁰ Ferdinando Castagnoli, *Orthogonal Town Planning in Antiquity*, trans. Victor Caliandro (Cambridge: MIT Press, 1971), 67-69.

¹³¹ Douglass M. MacDowell, *Aristophanes and Athens: An Introduction to the Plays* (Oxford: Oxford University Press, 1995), 210-211, 211 n. 19.

¹³² Hannah, *Greek & Roman Calendars*, 52.

¹³³ Matthew Amati, "Meton's Star-City: Geometry and Utopia in Aristophanes' *Birds*," *The Classical Journal* 105, no. 3 (2010), 213-214.

¹³⁴ *Ibid.*, 218.

¹³⁵ Wycherley, "Aristophanes, *Birds*, 995-1009", 23.

¹³⁶ MacDowell, *Aristophanes and Athens*, 211.

Ancient sources seem quite clear in their vision of Meton’s identity. In Latin works, Cicero refers to “Metonis annum” (“Meton’s year”) in a letter to Atticus;¹³⁷ Pliny the Elder cites him in as a source for the eighteenth book of his *Naturalis Historia*, which focuses on agricultural practices, crops, and the solstices;¹³⁸ Columella refers to him as an “astrologus” (“astronomer”) in his *De Re Rustica*;¹³⁹ and Hyginus says that he was an excellent observer of the stars.¹⁴⁰ From these sources it seems clear that the overarching identity of Meton in the Roman world at least was as an astronomer, whether because he is associated with his astronomical contributions or because he is explicitly described as such. In Greek, his name appears less frequently: here in *Birds*, in a fragment of Phrynichus, in the scholia on *Birds*, and a few other scholiast references mentioned in Hannah’s *Greek & Roman Calendars*.¹⁴¹ Leaving aside the current passage and the fragment of Phrynichus’s *Monotropos*, which I will discuss shortly, a scholiast on Meton’s entrance claims that he is ἄριστος ἀστρονόμος καὶ γεωμέτρης (“exceptional astronomer and geometer”).¹⁴² This seems to be the only reference outside the current passage and the Phrynichus fragment to refer to Meton as explicitly having *more than one identity* and to assert that he was anything other than an astronomer.¹⁴³ So, given that ancient consensus seems to gravitate towards “astronomer,” why do three modern scholars above insist that the real Meton was a “mathematician”, and why does one explicitly say that he was *not* a “geometer”? None of the above ancient references to Meton tie him to any explicit number manipulation, calculation, or mathematical geometry¹⁴⁴ other than whatever may be intrinsic to astronomy¹⁴⁵ and the scholiast’s assertion that he was a γεωμέτρης, which could refer either to mathematical or to literal geometry since no further context is given. It is possible that this primary association with mathematician is a Woozle-effect extending back to at least Wycherley;

¹³⁷ Cicero, *Epistulae ad Atticum* 12.3.2.

¹³⁸ Pliny the Elder, *Naturalis Historia*, 1.45.

¹³⁹ Columella, *De Re Rustica*, 9.14.12.6.

¹⁴⁰ Hyginus, *Astronomica*, preface 1.5.11.

¹⁴¹ See Hannah, *Greek & Roman Calendars*, p. 53. The references Hannah collates here all describe Meton’s astronomical activities and their impact on Athens.

¹⁴² F. Dübner, *Scholia Graeca in Aristophanem* (Paris: Didot, 1877 (repr. Hildesheim: Olms, 1969)): 209-247, <http://stephanus.tlg.uci.edu.ezphost.dur.ac.uk/Iris/Cite?5014:009:141674>, 997.

¹⁴³ Other scholia refer to his deme, but this identity is not the focus of this study.

¹⁴⁴ As opposed to literal geometry, i.e. land measurement.

¹⁴⁵ Astronomy can, and often does, entail a sizeable amount of calculation and other mathematical knowledge, but this math is usually done behind the scenes and not always visible in the results which are then brought to the public, and this math is not brought up in the sources I cite. The absence of the mathematics of astronomy in Meton’s mentions does not mean that Meton did no math, but rather that the math he may have done was subsumed into his identity of astronomer for these sources. The litmus test for group membership with *mathematicians*, after all, does not start and end with “Does this person do math?”

perhaps he or one of the German 19th century scholars he cites interpreted the scholiast's γεωμέτρης as “mathematical geometer”. On the other hand, do the ancient sources above *exclude* Meton from identifying as a mathematician, either in reality or as portrayed in *Birds*? Of course not, but if he did identify as a mathematician in reality, it was either not remembered well in antiquity or was secondary to his identity as astronomer. Otherwise, more sources would discuss his mathematical contributions outside of astronomy.

Most, if not all, of the ancient sources cited above, however, date after the debut of *Birds* and Phrynichus's *Monotropos*. So it is worthwhile to look at the passage isolated from these later sources in order to better understand the portrayal of Meton here and what identities he might have been dressed in here:

M: ἤκω παρ' ὑμᾶς—

Π: ἕτερον αὖ τουτὶ κακόν.

τί δ' αὖ σὺ δράσων; τίς δ' ἰδέα βουλευμάτος;

τίς ἢ ἴπινοια, τίς ὁ κόθορνος τῆς ὁδοῦ;

M: γεωμετρήσαι βούλομαι τὸν ἀέρα 995

ὑμῖν διελεῖν τε κατὰ γύας.

Π: πρὸς τῶν θεῶν

σὺ δ' εἶ τίς ἀνδρῶν;

M: ὅστις εἴμ' ἐγώ; Μέτων,

ὃν οἶδεν Ἑλλὰς χά' Κολωνός.

Π: εἰπέ μοι,

ταυτὶ δέ σοι τί ἔστι;

M: κανόνες ἀέρος.

αὐτίκα γὰρ ἀήρ ἐστι τὴν ἰδέαν ὅλος 1000

κατὰ πνιγέα μάλιστα. προσθεῖς οὖν ἐγὼ

τὸν κανόν' ἄνωθεν τουτονὶ τὸν καμπύλον,

ἐνθεῖς διαβήτην—μανθάνεις;

Π: οὐ μανθάνω.

M: ὀρθῶ μετρήσω κανόνι προστιθείς, ἵνα

ὁ κύκλος γένηταί σοι τετράγωνος, κὰν μέσῳ 1005

ἀγορά, φέρουσαι δ' ὥσιν εἰς αὐτὴν ὁδοὶ
ὀρθαὶ πρὸς αὐτὸ τὸ μέσον, ὥσπερ δ' ἀστέρος,
αὐτοῦ κυκλοτεροῦς ὄντος, ὀρθαὶ πανταχῆ
ἀκτῖνες ἀπολάμπωσιν.

Π: ἄνθρωπος Θαλῆς.

Μέτων—

1010

M: τί ἔστιν;

Π: οἶσθ' ὅτι φιλῶ σ' ἐγώ,
κάμοι πιθόμενος ὑπαποκίνει τῆς ὁδοῦ.

M: τί δ' ἐστὶ δεινόν;

Π: ὥσπερ ἐν Λακεδαίμονι
ξενηλατοῦνται καὶ κεκίνηνται τινες·
πληγαὶ συχναὶ κατ' ἄστν.

M: μῶν στασιάζετε;

Π: μὰ τὸν Δί' οὐ δῆτ'.

1015

M: ἀλλὰ πῶς;

Π: ὁμοθυμαδὸν
σποδεῖν ἅπαντας τοὺς ἀλαζόνας δοκεῖ.

M: ὑπάγοιμί τᾶρ' ἄν.

Π: νῆ Δί' ὡς οὐκ οἶδ' ἄρ' εἰ
φθαίης ἄν· ἐπίκεινται γὰρ ἐγγυς αὐταί.

M: οἴμοι κακοδαίμων.

Π: οὐκ ἔλεγον ἐγὼ πάλαι;

οὐκ ἀναμετρήσεις σαυτὸν ἀπιὼν ἀλλαχῆ;¹⁴⁶

1020

M: I've come to you—

P: Ach, another rascal here. You've come to do what, now? What sort of proposal? What's this contraption, these trekker's platform shoes?

M: I want to survey your air and allot it into acres.

¹⁴⁶ Aristophanes, *Birds*, 992-1020.

P: By the gods, who in the world are you?

M: *Who am I?* Meton, whom Greece knows and Kolonos too.

P: Tell me, what are these things of yours?

M: *Kanōns* for the air. Because to start off, the air, as a whole, is mostly shaped like a stove cover. Then I put the *kanōn* up here, this curved one, and insert a *diabētēs*—are you following?

P: No, I'm not.

M: I'll measure putting the *kanōn* straight, so your circle becomes squared, and in the middle an agora, and the streets lead right to it, straight towards the very center, just like the rays of a star, since that's round, shining out straight in every direction.

P: The man's a Thales. Meton—

M: What is it?

P: You know I adore you, so listen to me and back away from the road.

M: What's the alarm?

P: It's like in Sparta, some people drive out foreigners and take them out. Beatings are common throughout town.

M: Surely you're not in at odds with each other?

P: Oh, by Zeus, no, not at all.

M: Then what?

P: It's unanimously been decided to pound any and all charlatans.

M: Oh, then I should start running.

P: Well by Zeus I don't know if you'll outrun them, because the beatings are pretty damn close.

M: Ah! Curses!

P: Didn't I tell you before? Are you not going to measure yourself off some other way?¹⁴⁷

¹⁴⁷ Translations are my own.

Taking into consideration the last two sections on the references to “mathematics” in Aristophanes, what is noticeable in this passage is that μετρέω is used three times in three different compounds, the highest concentration of μετρέω verbs in all of Aristophanes. In the rest of Aristophanes, as we have seen, μετρέω is an action associated mostly with political acts and the agora, both of which are things that seem to be scorned by Peisthetairos in this passage and elsewhere. This is the view of Amati, drawing off of Jennifer Clarke Kosak’s observation that “the bird-city is mostly featureless” when he says “Nephelococcygia’s undifferentiated interior allows no space for debate, for addressing the citizenry, for worshipping the gods, for pursuing litigation... Without those spaces, Nephelococcygia can only be rigidly undemocratic.”¹⁴⁸ But the inclusion of γεωμετρῆσαι (995) harkens back to its only other occurrence in Aristophanes: the thought-shop in *Clouds*. There the act of γεωμετρέω has no political attachments, but rather seems completely abstracted from the normal uses of land measurement. Strepsiades, after all, asks if it is for measuring land in colonies, and the learner responds that it is for measuring any land.¹⁴⁹ In response, Strepsiades calls this kind of land measurement ἀστεῖον, which has connotations of “city” but not necessarily of “polis”. So there are two possible identities that could arise from the focus on μετρέω: politician and some type of “learned” city-quack along the lines of Sokrates in *Clouds*.

Although Wycherley claims that γεωμετρῆσαι here means something along the lines of “to apply [theoretical] geometrical methods to”,¹⁵⁰ this seems unlikely given that the joke derives its humor from the juxtaposition of γεωμετρῆσαι (“land measure”) and τὸν ἀέρα (“the air”). The suggestion of measuring air, which would appear boundless and unmeasurable, just as one measures land, which can be bounded and easily measured, is a very obvious pun, whereas the suggestion of applying theoretical geometry to the air seems obscure and does not correspond with the continuation of the joke, διελεῖν τε κατὰ γύαζ (“and allot it into acres”). Furthermore, the “geometry” scene is very focused on the instruments used to carry out this γεωμετρῆσαι. While in many cases of theoretical geometry the method by which one constructs a diagram that illustrates a proposition or proves a theorem is just as important as the resulting diagram, this is not quite what Meton’s description of his actions demonstrates. If we consider Proposition 1 of

¹⁴⁸ Jennifer Clarke Kosak, “The Wall in Aristophanes’ Birds”, Rosen and Sluiter (2006), 174, cited in Amati, “Meton’s Star-City”, 218.

¹⁴⁹ Aristophanes, *Clouds*, 200-205.

¹⁵⁰ Wycherley, “Aristophanes, Birds, 995-1009”, 23.

Book 1 of Euclid’s *Elements*, albeit in a later work but a relatively simple instance of the importance placed on the method of construction, the explanation of how to construct the equilateral triangle does not mention any instruments at all, but rather focuses only on what is drawn, as demonstrated by the third-person, perfect passive imperative γεγράφθω, a peculiar grammatical form that is often used in mathematical works.¹⁵¹ Thus the importance of the method is not signified by the instruments used, which for Euclid were implicitly restricted, but the results of their use, namely the circles (κύκλοι), lines ([εὐθεΐαι] γραμμαί), and points (σημεῖα). The scene here describes only the instruments, however, and how to arrange them (lines 1001-1004), until the end result is announced (the κύκλος in line 1005), so if this was a reference to theoretical geometrical methods, it would not be to Euclidean geometrical methods at least. Wycherley and Amati both dwell on the actual diagram supposedly drawn by these instruments, while MacDowell dismisses such “reconstructions” as “misguided”.¹⁵² Whether there was an actual diagram drawn on stage is certainly up for debate, and there is no way to be certain unless some miraculous vase depicting this scene pops up to point one way or the other. In any event, the assumption that a diagram was drawn on stage is dependent on the instruments being those of theoretical geometry. But the instruments themselves do not necessitate theoretical geometrical associations either. In my translation, I did not translate the instruments used, the κανών (*kanōn*) and διαβήτης (*diabētēs*). These are frequently translated as the mathematical straight-edge and compass, respectively, but ancient Greek carpenters used instruments with these same names, so the κανών and διαβήτης are not exclusively mathematical instruments. In *Clouds* the word διαβήτης appears when the first learner is telling Strepsiades about Sokrates stealing a *himation* from someone who is referred to as a διαβήτης.¹⁵³ Henderson in a footnote to his translation of *Clouds* says that this is a “double meaning of *diabetes* ‘compass’ and ‘one who spreads his legs,’” so it could be possible that that same kind of double entendre is employed here as well.¹⁵⁴ Considering the context of the joke, the focus of the explanation, and the nature of the instruments on stage, the γεωμετρήσαι here seems unlikely to refer to theoretical geometry as Wycherley claims. Accordingly, it would be a bit farfetched to claim that

¹⁵¹ Markus Asper, “The Two Cultures of Mathematics in Ancient Greece” in *The Oxford Handbook of the History of Mathematics*, Oxford Handbooks (Oxford, New York: Oxford University Press, 2008), 118-119.

¹⁵² MacDowell, *Aristophanes and Athens*, 210.

¹⁵³ Aristophanes, *Clouds*, 177-179.

¹⁵⁴ Jeffrey Henderson, *Aristophanes II: Clouds, Wasps, Peace* (Cambridge: Harvard University Press, 1998), 30 n. 15.

Meton is portrayed as a theoretical mathematician in this scene based on the inclusion of this word. If γεωμετρῆσαι refers to the same land-measurement that is referenced in *Clouds*, it may well point more in the direction of land-measurement tools, like the one Strepsiades must have seen in the thought-shop in lines 200-205.

Meton is called a “Thales” in line 1009. Thales is mentioned in *Clouds* as well: after the description of Sokrates stealing the *himation*, Strepsiades wonders τί δῆτ’ ἐκεῖνον τὸν Θαλῆν θαυμάζομεν (“why do we marvel at that Thales guy?”). This raises the implication that Sokrates, by stealing the *himation*, is a “better” version of Thales. Later Aristotle would also depict this “swindler” side of Thales in recounting how Thales predicted a great olive harvest and rented all of the olive presses himself so that he had a monopoly on lending them to others for a high price.¹⁵⁵ However the closest source chronologically to Aristophanes for references to Thales is Herodotus. Herodotus mentions Thales in three places: first in 1.74 where Thales predicts an eclipse, then in 1.75 where Thales builds a canal to get troops across a river, and lastly in 1.170 where Thales encourages the Ionians to centralize their government in Teos. These vignettes show multiple other sides of Thales that could have been in the minds of audience members. In the first mention, 1.74, Thales is an astronomer who predicts an eclipse, and interestingly Meton is called a Thales immediately after he gives his description of a star and its rays, which would be the most visible in an eclipse. Turning to a different side, in 1.75, immediately after Thales’s identification with astronomers, he is portrayed as an engineer, and a useful one. Herodotus claims that the story about Thales in 1.75 is ὁ πολλὸς λόγος Ἑλλήνων (“the great tale amongst the Greeks”), which seems to mirror Meton’s claim that all of Greece knows him, not just Athens. Much later in the first book Thales is said to have taken an interest in the politics of Ionia, telling the Ionians to hold one council in Teos in the middle of Ionia. Herodotus says this might have made the Ionians the most powerful Greeks, if the Ionians had listened. Thus Herodotus does not seem as distrustful of Thales as Aristophanes and presents him in a variety of costumes. Herodotus’s kinder views of Thales could be due to the proximity of their birthplaces, both being in Asia Minor, whereas Aristophanes was firmly rooted in Athens, but this cannot be certain. But given that Aristophanes has used Thales’s name pejoratively before, the “swindler intellectual” version of Thales seems to be the most likely version being projected onto Meton in *Birds*. This

¹⁵⁵ Aristotle, *Politics*, 1.11 1259a9-18.

is not to say that the versions of Thales found in Herodotus do not find echoes in the passage, as they certainly do, but these parallels are more likely to be coincidental.

Shifting now to other words put into Meton's mouth, before embarking on the instrument display discussed earlier, Meton compares the air to a *πνιγέυς*, a sort of cover for a stove. This reference, like the Thales reference, also appears in *Clouds*, when Strepsiades is telling his son about the thought-shop:

ψυχῶν σοφῶν τοῦτ' ἐστὶ φροντιστήριον.
ἐνταῦθ' ἐνοικοῦσ' ἄνδρες οἱ τὸν οὐρανὸν
λέγοντες ἀναπεύθουσιν ὡς ἔστιν πνιγέυς,
κάστιν περὶ ἡμᾶς οὗτος, ἡμεῖς δ' ἄνθρακες.¹⁵⁶

This is a thought-shop of wise souls. Inside live men who persuade in words that the heaven is a *πνιγέυς*, and this is around us, and we are charcoals.

To this reference there is a scholium which attributes this peculiar analogy to the philosopher Hippo.¹⁵⁷ While Hippo's origins vary throughout his testimonies, it is likely that he was known in Athens in the fifth century BCE, especially if we believe the scholium's claim that Kratinos made fun of Hippo for this same thing in his play *Panoptai*.¹⁵⁸ In the sixth century CE Simplicius in his *Commentary on Aristotle's Physics* closely associates Hippo with Thales for both believing water to be the first principle element, but this is nearly a thousand years after Aristophanes's time.¹⁵⁹ However, this specific view of the heavens is only attributed to Hippo in this scholium, so it is very possible that the attribution is not real. Whether it is genuinely Hippo's view or not, it does not seem coincidental that this *πνιγέυς* analogy comes up in two contexts otherwise noted for intellectual quackery. What is more is that this reference is not associated with Hippo or any other name by Aristophanes himself, except that he puts it in

¹⁵⁶ Aristophanes, *Clouds*, 94-97

¹⁵⁷ D. Holwerda, *Prolegomena de comoedia Scholia in Acharnenses, Equites, Nubes (Scholia in Aristophanem 1.3.1)* (Groningen: Bouma, 1977): 1-250, <http://stephanus.tlg.uci.edu.ezphost.dur.ac.uk/Iris/Cite?5014:003:40479>, 96d.

¹⁵⁸ *Ibid.*

¹⁵⁹ Simplicius, *In Aristotelis physicorum libros commentaria*, 23.22-23.

Meton’s mouth in the *Birds* scene, implying that if indeed some intellectual did hold this view, either everyone knew who it was that held it, or it no longer mattered who originated it because it was a common quack saying. It could be of similar repute to Hegelochus’s infamous pronunciation mistake: when brought up in comedy, the joke often does not name Hegelochus specifically, but the reference was so well known to the audience that they did not need it. However the *πνιγεύς* analogy arose and whatever its associations, it is clear that it is a jab at intellectual quacks, and this jab is transferred onto Meton.

It is worth mentioning here that Meton appears not just in *Birds*, but in another comedy staged around the same time as *Birds*.¹⁶⁰ Phrynichus in *Monotropos* wrote:

[A]: τίς δ' ἔστιν ὁ μετὰ ταῦτα φροντίζων;
 [B]: Μέτων,
 ὁ Λευκονοιεύς.
 [A]: οἶδ', ὁ τὰς κρήνας ἄγων.¹⁶¹

[A]: Who is that guy thinking after all this?
 [B]: Meton, from Leukonoion.
 [A]: I know him, the one drawing the fountains.

Here Meton’s memorable characteristic is that he “draws fountains,” which according to the same scholium that preserves this fragment refers to either a fountain (κρήνη), a statue (ἄγαλμα), or an astrological contraption (ἀνάθημα ἀστρολογικόν) in the deme Kolonos.¹⁶² Meton is otherwise known to have “erected an instrument called a *heliotropion* in the political assembly area on the Pnyx hill”,¹⁶³ so this fragment is further evidence of Meton’s visible contraptions around Athens. From the instrument scene in *Birds* and the Phrynichus fragment above, Meton has an air of hyper-visibility in Athens: part of his comedic character is that he carries around instruments and sets up strange contraptions which the rest of Athens does not understand. If Meton actually did carry large instruments around Athens, it would be no surprise if this was

¹⁶⁰ Dübner, *Scholia Graeca in Aristophanem*, 997.

¹⁶¹ Phrynichos 22=Scholium to Aristophanes’s *Birds* 997.

¹⁶² Dübner, *Scholia Graeca in Aristophanem*, 997.

¹⁶³ Hannah, *Greek & Roman Calendars*, 53.

what he became known for and comedians exploited it on stage. Due to Meton's work on the calendar, and taking apart the name *heliotropion*, Meton must have been looking into the sky a lot, possibly with the help of his gadgets. This behavior is easily converted into the set-up of the *Birds* scene where Meton is using instruments to measure the sky. Even if the real Meton did none of this, it is clear that Meton on stage has an engineering side to him, and possibly a strange obsession with staring at the sun.

So what does this mean for Meton? Who is he really? We may hesitate to extrapolate some features to the real Meton, but stage Meton has a few definite characteristics. From the *Birds* passage and the Phrynichus fragment, it is clear that Meton had name recognition among the audience and was visible out and about in Athens. For whatever reasons, Meton was famous. The association between Meton and instruments on stage gives the impression that Meton was famous for using or at least possessing large contraptions which were also visible around Athens. The kinds of people most likely to be using large contraptions would be engineers or literal geometers, i. e. land-measurers. Despite what scholars like Wycherley and Amati claim, it seems unlikely that the audience would have connected Meton to astronomy or theoretical geometry, as there is little evidence of contemporary astronomical topics or theoretical geometric principles in the *Birds* scene. However, Meton was certainly a swindling intellectual quack. Not only does the Meton scene display this through its overall function within the play, but also through its references to other quackery like Thales and the *πνιγεύς* analogy, references which reflect back on *Clouds*, well-known as the ultimate shot at intellectual quacks in Athens. "Town-planning" does not seem to be the focus of Meton's identity in *Birds*, although Amati is convincing in his argument that the idea of planning a town is antithetical to the whole bird-city project. In this respect Meton seems to be a town-planner for plot purposes only, not necessarily because the real Meton helped plan cities (much to the chagrin of Castagnoli and Ehrenberg). So in sum, Meton to the audience at most may have been a tin-foil-hat-wearing, intellectual quack who looks at the sky all day and builds weird things in public spaces.

But then, if this is how the audience viewed Meton, how could later ancient sources almost unequivocally deem him an astronomer? There seems to be a disconnect between the popular idea of an astronomer and the "academic" idea of an astronomer, particularly that astronomy in the popular eye of fifth century Athens may have looked little different from run-of-the-mill sophistry, just with more gadgets and gizmos to ogle. Alternatively, popular ideas of

“astronomer” may have had blurrier boundaries separating it from other professions like “geometer” and “engineer,” or even that the audience did not understand the role of “astronomer” at all. In support of the latter is that Peisthetairos has no idea what Meton is doing, as evidenced by his curt οὐ μανθάνω when asked if he is following, and at the end of the explanation Meton is immediately lumped in with all the other Thales-type characters of the day. A still third, and in fact likely, explanation is that Meton’s astronomical abilities were known to at least some of the audience, but Aristophanes (and Phrynichus, and potentially others) did not choose to display them on stage more than having Meton describe a star. There are many other references to the confusing nature of the Athenian calendar in Aristophanes (see previous two chapters), and Meton made his 19-year cycle public around 433/432 BCE.¹⁶⁴ Clearly the Athenian public had informed opinions about the calendric chaos of the fifth century, so it would not be out of line to assume they knew Meton played a part in it. But on stage, Meton was not funny as an astronomer. Meton was funny as an intellectual city-quack, just as Sokrates in *Clouds* was not a perfect recreation of the real Sokrates. With this third option, it would seem that astronomy was funnier when its astronomical essence was stripped away, leaving the gadgets and quackery for all to see.

¹⁶⁴ Ibid.

5. Non-Aristophanic Old Comic Fragments

In late 2020, Hannah Čulík-Baird instilled some hope in the field of fragmentary studies:

Even though fragments often live in the periphery of our discipline...it is important to remember that fragments, for the most part, represent something that was very famous in antiquity, but which is now difficult to access. Fragments made via enclosure – i.e. because they were quoted by ancient authors – are (generally) preserved precisely due to their authoritative status in antiquity...For the most part, then, what is contained within an ancient fragment was very famous at the time that the quotation (or enclosure) was made.¹⁶⁵

Čulík-Baird reminds us that “fragment” does not necessarily have to imply “loss”. The loss of the whole work, while tragic, is not the end of the road. Rather, the nature of fragments allows us to gain insight into why an author was important, and why what they had to say was important to those who followed them. This idea is latent in already-held views like those of Heinz-Günther Nesselrath in his discussion of why Middle Comedy lacks fragments in certain authors while Old and New Comedy abound in those same authors,¹⁶⁶ but it seems to be rarely acknowledged. In a sense fragmentary studies can appear very much like reception studies, and the two fields would appear to overlap quite a bit. Whether the lack of acknowledgement of this similarity is further evidence of the marginalization of reception studies within classics¹⁶⁷ would be a topic for another paper. Needless to say, I adopt the optimistic outlook of Čulík-Baird in approaching these fragments to come. It does not seem to be an over-step to investigate the impact mathematics in ancient Greek comedy had on later authors. The presence of mathematics outside Aristophanic comedy confirms that mathematics was not just an Aristophanic topic: other

¹⁶⁵ Hannah Čulík-Baird, “The Fragment and the Future,” Swansea Lecture Series 2020-2021 (Swansea University, Swansea, Wales, November 23, 2020), accessed May 10, 2020, <https://opietasanimi.com/2020/11/23/the-fragment-and-the-future-swanea-lecture-23rd-nov-2020-audio-text/>.

¹⁶⁶ Heinz-Günther Nesselrath, “Comic Fragments: Transmission and Textual Criticism,” in *Brill’s Companion to the Study of Greek Comedy*, ed. Gregory W. Dobrov (Leiden: Brill, 2010), 433-434.

¹⁶⁷ See Patrice D. Rankine, “The Classics, Race, and Community-Engaged or Public Scholarship,” *American Journal of Philology* 140, no. 2 (2019), 345-359, especially 353-357.

comedians thought there were aspects of mathematics worth satirizing and including in their plays.

Before looking at the actual fragments, it is worthwhile to examine the state of each topic, where these fragments are sourced, and their contexts within the works from which we receive them today. In collecting these fragments, I mainly used Ian Storey's *Fragments of Old Comedy* volumes I to III from the Loeb Classical Library¹⁶⁸ in addition to the collection of fragments by Kassel and Austin from De Gruyter, the *Poetae Comici Graeci*.¹⁶⁹ A breakdown of the mathematical topics, how many fragments fit that topic, how many comic writers are cited for that topic, how many ancient sources constitute the fragments for that topic, and what percent of these fragments are quoted (or summarized) for that topic (i.e. Athenaeus quotes a fragment with a cognate of λογίζομαι *because of* that cognate or a reason related to that cognate) can be found in Table 3. Note that two additional topics have been added to increase the scope of this section, namely "wine ratios" and "gambling," as these involve numbers interacting with each other, resulting in different outcomes depending on the numbers (e.g. 4 parts wine to 2 parts water being undrinkable, or three rolls of 6 meaning a winning roll). Some fragments belong to multiple topics, in which case I have included the fragment in the count for each topic referenced in it, but most only fall into one of the above topics. Furthermore, a few fragments are cited by multiple sources, in which case I have included each source in the count if it was not represented already by another fragment, enabling the 5 fragments falling under the "Names" topic to have 6 unique sources for them. Lastly, each different papyrus would have counted separately as an ancient source, but only one papyrus fragment was relevant to this study.

¹⁶⁸ Ian C. Storey, *Fragments of Old Comedy Volume I: Alcaeus to Diocles* (Cambridge: Harvard University Press, 2011); Ian C. Storey, *Fragments of Old Comedy Volume II: Diopēithes to Pherecrates* (Cambridge: Harvard University Press, 2011); Ian C. Storey, *Fragments of Old Comedy Volume III: Philonicus to Xenophon, Adespota* (Cambridge: Harvard University Press, 2011).

¹⁶⁹ *Poetae Comici Graeci Volumen II: Agathenor - Aristonymus*, ed. Rudolf Kassel & Colin Austin (Berlin: De Gruyter, 1991); *Poetae Comici Graeci Volumen IV: Aristophon - Crobylus*, ed. Rudolf Kassel & Colin Austin (Berlin: De Gruyter, 1983); *Poetae Comici Graeci Volumen V: Damoxenus - Magnes*, ed. Rudolf Kassel & Colin Austin (Berlin: De Gruyter, 1986); *Poetae Comici Graeci Volumen VII: Menecrates - Xenophon*, ed. Rudolf Kassel & Colin Austin (Berlin: De Gruyter, 1989). In referencing fragments I will use the numbering of Kassel-Austin with the ancient author cited as in Storey's Loeb's (n. 8) for ease.

<i>Topic</i>	<i>How many (attributed) fragments?</i>	<i>How many comic writers?</i>	<i>How many ancient sources?</i>	<i>Percent quoted/summarized for topic</i>
λογίζομαι and cognates	5	3	4	60%
ἀριθμέω and cognates	5	4	5	40%
μετρέω and cognates	5	3	4	60%
μανθάνω and cognates	14	7	11	14.28%
Astronomy	6	5	6	33.33%
Weights and measures	17	9	5	47.06%
Coins and Money	32	14	11	40.625%
Taxes	9	4	6	44.44%
Treasury	2	1	2	100%
Wine Ratios	11	9	1	81.82%
Gambling	3	2	3	66.67%
Names	5	3	6	60%

Table 3: Breakdown by Topic of Old Comic Fragments

From this table some biases become glaringly obvious: references to wine ratios are cited exclusively in one source (Athenaeus), only a small proportion of μανθάνω and cognate words are being actively recalled by the sources (only 1/7 of the total for that topic), and references to the treasury and treasurers are only recalled when directly relevant to treasurers themselves (and neither fragment is a direct quote from a work). These biases are to be expected, as discussed above, and they show that some topics were more consciously on the minds of these lexicographers, scholiasts, deipnosophists, etc., than others. Some topics, like μανθάνω and its cognates, were seemingly just “along for the ride” so to speak, as most such words are fortuitously still preserved as a result of another word in the fragment being more interesting to the source author. On the other hand, a topic like wine ratios was forefront in the mind of Athenaeus: many are found in a single section of his work devoted to wine ratios in antiquity, resulting in 11 fragments, for which 9 were explicitly quoted because they contained a wine ratio. That being said, most topics fall somewhere in the 40-60% range in the last column, meaning that most topics include a few words that grabbed the attention of an ancient source, whereas other words were overshadowed by other words in the fragment. These percentages should not

be taken to denote *interest level* in each topic, as that interpretation quickly runs into problems with the topic of “treasury” with 100% of its fragments directly related to the topic contextually but only two fragments total.

Of the ancient sources which preserve fragments relevant to this study, the most commonly occurring are Photius, Athenaeus, and Pollux. This is not surprising, as in the whole corpus of comic fragments these three feature prominently as important sources.¹⁷⁰ Photius¹⁷¹ and Pollux¹⁷² were writers of lexica, trying to document peculiar phrases and words, especially Atticisms not present in their day, so it is logical that they would look to comedy for entries. Athenaeus wrote the *Deipnosophistai*, which catalogued learned people’s dinner parties with copious references to comedy for evidence of various fish, birds, dishes, dinner behavior, moochers, etc.¹⁷³ While Photius wrote his lexicon in the ninth century CE, Athenaeus and Pollux lived around the third century CE, much closer to the time when ancient comedy was performed in Athens, but still centuries later.¹⁷⁴ The prominence of the lexicographers especially demonstrates the fact that many of these words were no longer in common parlance by Pollux’s time, warranting their entry into the lexica of the day. In terms of the study here, this means that some mathematical words from comedy had become obsolete, or that comedians had made up mathematical-sounding words that caught the attention of lexicographers later, or both. The continued prominence of Athenaeus when shifting from gastronomic to mathematical content is also significant: mathematics and food may not seem like a common pairing, but many references to mathematics are preserved in the gastronomic world of Athenaeus’s *Deipnosophists*. It will be prudent to remember, as Anne Carson has noted in the case of Simonides in Plato’s *Protagoras* (“Whatever it is that Simonides is trying to say in this poem is not what the philosophers get out of it”),¹⁷⁵ authors quote fragmentary authors for their own interests, not the interests of those whom they quote, and as such it is possible that fragments can take on meanings their authors never intended. Accordingly, the fragments preserved by Athenaeus were not necessarily in a banquet context in their original plays, even though Athenaeus may have deployed them in one. Nevertheless, the spheres of mathematics and

¹⁷⁰ See Nesselrath, “Comic Fragments,” cited in n. 166, especially pp. 424-430.

¹⁷¹ Nesselrath, “Comic Fragments,” 424-425.

¹⁷² *Ibid.*, 427-428.

¹⁷³ *Ibid.*, 426-427.

¹⁷⁴ *Ibid.*, 424-428.

¹⁷⁵ Anne Carson, “How Not to Read a Poem: Unmixing Simonides from ‘Protagoras,’” *Classical Philology* 87, no. 2 (1992), 128.

culinary arts seem to have some overlap. A number of other authors employ comic fragments with mathematical references for still other motivations.

While we may not be able to “piece together” the lost comedies represented here (and, again, this is not the goal), we can still increase our understanding of mathematics in ancient comedy through the fragments we have. As will be seen, these fragments will attest to some of the possibilities above: absurd νομίσματα feature in Pherekrates’s *Karpataloi*, an obscure Boiotian measurement appears in a comedy of Strattis, and people are said to mix wine with ratios in a number of plays. For some of these fragments, we have some information about their parent play, but for many we do not. Therefore in general we cannot extrapolate from these fragments to theorize the overall content of their parent plays, but we will be able to see whether or not these mathematical nuggets are appearing in order to satirize mathematics itself. Most importantly, these fragments will give us more insight into what an average Athenian audience member would consider μαθήματα and mathematics.

Given that there are many more authors and works represented by the extant Old Comic fragments than what survives of Aristophanes, it is in one sense unsurprising that a substantial number of fragments make reference to mathematics. On the other hand, given the number of actual lines preserved by the fragments as compared to the number of extant lines of Aristophanes, the frequency of mathematical references in the fragments *is* surprising. Just over 46% of the fragments discussed here are preserved because of their mathematical reference, so this could be part of the reason that there seems to be a surprising amount of mathematics in the fragments compared to Aristophanes. With this potential sample bias in mind, the fragments do paint a slightly different picture of mathematics than what we saw in Aristophanes.

Instances of words that share roots with μανθάνω appear in at least seven authors: Arkhippos, Krates, Kratinos, Eupolis, Pherekrates, Phrynikhos, Platon, and one anonymous fragment. Most are verb forms of μανθάνω, but ἀμαθής appears twice and ἀμάθητος once. The last of these appears only as the word itself without context in the Antiatticist, where it is said to come from Phrynikhos’s *Konnos*.¹⁷⁶ Storey in the Loeb edition of *Fragments of Old Comedy* ponders whether this play is distinct from the better-attested play of the same name by Ameipsias,

¹⁷⁶ Phrynikhos 8=Antiatticist p. 79.2 (fragment numbers used are those found in Kassel and Austin, *Poetae Comici Graeci*, De Gruyter).

or, alternatively, perhaps *Konnos* (ΚΟΝΝΟΣ) is a misreading of *Kronos* (ΚΡΟΝΟΣ).¹⁷⁷ Seeing as Ameipsias's *Konnos* competed at the same festival as Aristophanes's original *Clouds* (at the Dionysia of 423),¹⁷⁸ placed above it, and may have had a chorus of "deep thinkers" (φροντισταί),¹⁷⁹ it would serve this paper well if this Phrynikhos fragment could be attributed to the Ameipsias play, but there is no way of knowing for certain. The adjective ἀμαθής occurs in two different fragments:

λόγος τις ὑπῆλθ' ἡμᾶς ἀμαθῆς σοβαύβαλος.¹⁸⁰

Some unlearned (ἀμαθῆς), swineherd tale duped us.¹⁸¹

ἀμαθῆς σοφός, δίκαιος ἄδικος¹⁸²

An unlearned (ἀμαθῆς) man[?] is wise, a just unjust.

Both of these fragments are not assigned to specific play titles. What can be said about their contexts is that Arkhippos's heyday seems to have been around the year 400 and after,¹⁸³ while Kratinos appears to have died shortly after 423,¹⁸⁴ so it is safe to say Kratinos's fragment predates Arkhippos's (assuming both are genuine). In Kratinos's line, ἀμαθῆς describes the tale (λόγος), but so does the adjective σοβαύβαλος. While there can be no certainty, especially without even a play title attached to the line, the unlearnedness of the tale could have stemmed from its source, namely the swineherd; ἀμαθῆς is separated from λόγος by almost half a line in order to juxtapose σοβαύβαλος. This hyperbaton equalizes both adjectives, strengthening the association between them. Depending on the original context of this line, it could have served to

¹⁷⁷ Ian C. Storey, *Fragments of Old Comedy: Volume III, Philonicus to Xenophon, Adespota* (Cambridge: Harvard University Press, 2011), 53.

¹⁷⁸ Hypothesis V *Clouds*.

¹⁷⁹ Athenaeus 218c.

¹⁸⁰ Kratinos 345=Eustathius *On the Odyssey* p. 1761.27.

¹⁸¹ All translations are my own, but in consultation with Storey's translations in the Loeb edition considering the brevity of many of the fragments.

¹⁸² Arkhippos 51=Bachmann's *Lexicon* p. 29.28.

¹⁸³ Ian C. Storey, *Fragments of Old Comedy: Volume I, Alcaeus to Diocles* (Cambridge: Harvard University Press, 2011), 94-97.

¹⁸⁴ *Ibid.*, 234-237. See also Lucian *Long-Lives* 25 and Aristophanes *Peace* 700-703.

joke about the ignorance of swineherds, potentially of the larger farming population. Eustathius cites it alongside a definition of βαυβᾶν (“to sleep”), so σοβαύβαλος must have a connotation of somnolence as well. The Arkhippos fragment is even more difficult to interpret: it could be a remarkably elliptical and asyndetic line, or it could be a simplification of a more fleshed out passage. In Bachmann’s *Lexicon* this is cited for the entry ἄδικος (“unjust”), and it goes on to explain ἀμαθῆς as {μηδὲν} φύσει εἰδώς (“knowing nothing by nature”). Whatever may lie behind the fragment, as we have it we have a string of four adjectives in the masculine, which suggests four substantive adjectives with an implied masculine noun (I chose “man” above, but it would have depended on the surrounding context). There are many possibilities for the original context for this line. The chiasmus of alpha-privative and unmodified adjectives seems to suggest an inversion and confusion of values. Perhaps it was a stab at people who proclaim themselves to be “wise” and “just”, saying that they are actually all uneducated crooks. Because of the lack of context for these fragments, it is difficult to say whether these cognates of μανθάνω have anything to do with calculation.

On the other hand, the verb forms of μανθάνω tend to occur with more context, or at the very least are associated with a play title. Of the twelve occurrences, six seem to correspond to gaining knowledge, three to learning skills, two are idiomatic uses (both versions of τί μαθών, meaning “why in the world”),¹⁸⁵ and one is unclear. Eupolis has a line where a character “was learning many things at the barber shop” (πόλλ’ ἔμαθον ἐν τοῖς κουρείοις) while feigning ignorance to avoid suspicion in the comedy *Marikas*,¹⁸⁶ Pherekrates prefaces what appears to be a “fun fact” with μανθάνεις; (“Do you know?”) in *Korianno*,¹⁸⁷ and Platon interjects a μανθάνω between two misogynistic claims in *Europa*.¹⁸⁸ In regard to learning skills, Kratinos has someone sing and learn (μανθάνει) music,¹⁸⁹ and Eupolis has a character scold an old man for accepting a payment for enlisting in the Athenian cavalry before he had learned horseback-riding (μαθεῖν τὴν ἵππικὴν).¹⁹⁰ The one unclear instance is a parenthetical μανθάνεις; in the middle of a grammatically independent line:

¹⁸⁵ Eupolis 193=Plutarch *Nikias* 4.3; Pherekrates fr. 70=Athenaeus 612a.

¹⁸⁶ Eupolis 194=Scholium to Plato *Sophist* 239c.

¹⁸⁷ Pherekrates 74=Athenaeus 653a.

¹⁸⁸ Platon 43=Athenaeus 367c.

¹⁸⁹ Kratinos 338=Scholium to Aristophanes *Knights* 1287.

¹⁹⁰ Eupolis 293=Harpocration p. 170.7.

ἡμίεκτόν ἐστι χρυσοῦ (μανθάνεις;) ὀκτῶ ὀβολοί.¹⁹¹

A half-*hekteus* of gold is (do you follow?) eight obols.

Without more context this use could fall almost anywhere on the spectrum of “understand” to “learning”. The line without the *μανθάνεις*; could be a simple assertion, that a half-*hekteus* of gold is eight obols, and the speaker noticed that the listener was distracted (“Do you understand?”). Seen differently, the speaker could be explaining what a half-*hekteus* of gold should be worth, perhaps in order to dispatch the listener to sell one, in which case the speaker is instructing them in order to ensure that they accept nothing less (“Are you learning?”). However, considering a half-*hekteus* of gold would be quite a substantial volume (maybe about a gallon),¹⁹² 8 obols would seem to be a ridiculously low value for it, so this could be a joke relating to the impurity of some specific gold (as a large amount of impure gold would be worth less) or to an absurd scenario where gold is inherently less valuable. Thus the parenthetical *μανθάνεις*; most likely serves to emphasize the absurdity of the ensuing equivalency. It is known that this fragment is from Krates’s *Lamia*, but this gives little help: nothing is known for certain about its plot, and the title and remaining fragments cannot reliably elucidate any themes or plot points.¹⁹³

One of the longer but unfortunately unassigned fragments of Eupolis warrants closer examination:

ἀλλ’ ἀκούετ’, ὦ θεαταί, τὰμὰ καὶ ξυνίετε
ρήματ’, εὐθὺ γὰρ πρὸς ὑμᾶς πρῶτον ἀπολογήσομαι.
ὅ τι μαθόντες τοὺς ξένους μὲν λέγετε ποιητὰς σοφούς,
ἦν δέ τις τῶν ἐνθάδ’ αὐτοῦ μηδὲ ἐν χεῖρον φρονῶν
ἐπιτιθῆται τῇ ποιήσει, πάνυ δοκεῖ κακῶς φρονεῖν,
μαίνεται τε καὶ παραρρεῖ τῶν φρενῶν τῷ σῶ λόγῳ.
ἀλλ’ ἐμοὶ πείθεσθε, πάντως μεταβαλόντες τοὺς τρόπους

¹⁹¹ Krates 22=Pollux 9.62.

¹⁹² Of course, quantifying gold by volume rather than by weight is unusual, but perhaps the lost context of the line would bring some sense or clarify that somehow the half-*hekteus* here is meant to be taken as a unit of weight.

¹⁹³ Storey, *Fragments of Old Comedy I*, 219-223.

μη φθονεῖθ' ὅταν τις ἡμῶν μουσικῇ χάριη νέων.¹⁹⁴

But listen, spectators, and hear what I have to say, for I'll defend myself straightaway first in front of you all. Whatever you've learned (μαθόντες), you say that the foreigners are wise poets, and if anyone of these here [i.e. the spectators], even if he has not one worse thought than him, makes an attempt at poetry, he seems to have entirely terrible ideas, goes into a frenzy, and then escapes his senses in your account. But believe me, seeing as you completely changed gears, don't get mad when one of us young people enjoys music.

This fragment addresses the audience directly and gives them a scolding for treating “foreigners” (ξένους) better than Athenians. Whoever the speaker is says that the audience's misconception of non-Athenian poets has something to do with what they have learned, and as a result of this learning they should not begrudge the youth for enjoying music. This seems a bit cryptic, but it does seem a bit clearer if we look at another fragment of Eupolis's with *μανθάνω*, this time where the thing learned is a skill:

καὶ ζῆν μαθόντι μηδὲ τάγυρι μουσικῆς.¹⁹⁵

...and for him to live, having learned not even a lick of music.

We briefly discussed Kratinos using *μανθάνω* with music just above. This fragment is from Eupolis's *Aiges*, a play for which there is some knowledge. Seemingly similar in concept to Aristophanes's *Clouds*, *Aiges* involved a teacher of grammar (γραμματική) and music (μουσική), a chorus of goats, a character from the country (ἄγροικος), and a teaching scene where the taught character fails miserably.¹⁹⁶ From these details, it is easy to envision this fragment as the teacher speaking disparagingly of the country-raised character. If indeed this was the case, and the

¹⁹⁴ Eupolis 392=Stobaeus 3.4.32.

¹⁹⁵ Eupolis 4=Photius p. 564.17.

¹⁹⁶ Ian Storey, *Eupolis: Poet of Old Comedy* (Oxford: Oxford University Press, 2003), 67-71.

teacher was the bigger butt of the joke in this play much like Sokrates in *Clouds*, the unassigned fragment might make a bit more sense. In the unassigned fragment, the scolder in essence says that the audience should not get angry if their children enjoy music since that is exactly what they are instilling in them through their flawed education. Thus the “learning” referred to in Eupolis 392 is connected with xenophilia, youth corruption, and hypocrisy, all unbeknownst to the audience members, who embrace this learning. These two fragments, then, seem to create an overall critical and negative view of *μανθάνω* learning. This conclusion is hard to fit in with the third Eupolis fragment with *μανθάνω*, mentioned above, especially without more context,¹⁹⁷ so we cannot say anything about Eupolis’s general attitudes towards *μανθάνω* learning.

There are six fragments containing a word related to *λογίζομαι*. Interestingly, while Aristophanes contained only forms of the verb, these fragments demonstrate a much more diverse array of cognates: verb forms of *λογίζομαι* and a compound of it, *ἐκλογίζομαι*, account for only two of these references. Two others contain the noun *λογιστής*, another has the noun *ἄλογιον*, and the last has the interesting adverb *ἀνεκλογίστως*. The one form of the uncompounded *λογίζομαι* occurs in Philonides 4:

περὶ δ’ ὧν σὺ λέγεις, λόγος ἐστὶν ἐμοὶ πρὸς Ἀθηναίους κατὰ χειρός,
ὄν ἐγὼ λογιῶμ’ ἐξ ἀτελείας, τῷ δήμῳ δ’ οὐδὲν ἀνοίσω.¹⁹⁸

Concerning what you’re talking about, I have an account at hand about [against?] the Athenians which I myself will reckon (*λογιῶμ’*) untaxed (*ἐξ ἀτελείας*), and I won’t bring any of it up with the people.

This comes from a play called *Kothornoi* (a type of shoe), whose plot is not clear. Storey suggests that Theramenes, a politician “who invariably came out on the right side of any issue,” may have something to do with the play based on him being called *Kothornos* and Philonides 6 (which consists of just the name Theramenes, in the vocative).¹⁹⁹ In addition to the form of

¹⁹⁷ Storey posits that this fragment (Eupolis fr. 293) may be evidence of “a comic teaching scene where the old man learns just what being a *hippeus* is all about.” See Storey, *Eupolis*, 264-265.

¹⁹⁸ Philonides 4=Photius (b, z) α 2024.

¹⁹⁹ Storey, *Fragments of Old Comedy III*, 13.

λογίζομαι, this fragment contains the word ἀτέλεια, which I have translated as “untaxed”. Fawcett says that ἀτέλεια “was granted for a number of reasons that often seem to merge with each other, including honoring particular individuals...fiscal incentives, and block grants to groups as part of treaty arrangements between states.”²⁰⁰ While this instance of ἀτέλεια may not necessarily denote literal tax exemption, this shady dealing could have been part of an actual political dealing. Taking the fragment quoted above with Philonides 5:

παναγῆς γενεά, πορνοτελῶναι, Μεγαρεῖς δεινοί, πατραλοῖαι²⁰¹

Completely accursed bloodline, tax-whores, terrible Megarians,
father-slayers

it is possible to imagine the speaker of Philonides 4 extorting someone else (presumably an Athenian), as ἀτέλεια would then relate to the πορνοτελῶναι. Alternatively, if πορνοτελῶναι is to be taken as an actual official position, “the farmers of the prostitutes’ tax,” perhaps the common link is still taxation, but only coincidentally.²⁰² This alternative interpretation of Philonides 5 could mean that Megarians were known for taxing sex work, or that Megarians resident or publicly enslaved in Athens constituted a large proportion of the πορνοτελῶναι. However, considering the dearth of information for this play, these interpretations run the risk of inflating the facts. From S. Douglas Olson’s thought experiment of reconstructing the extant plays of Aristophanes from the fragments in Athenaeus’s *Deipnosophistai*, it is clear that a complete reconstruction of lost material can go wrong very easily.²⁰³ After detailing the pitfalls that scholars are liable to fall into when attempting a reconstruction from fragments, Olson concludes that “[a]ttempts at reconstruction that assume that the broken pieces of a comedy we have can be made to fit neatly together as part of a coherent, logical whole thus approach the problem from a misguided direction, and the cleverer the scheme, and the more elaborate effort to give all the

²⁰⁰ Peter Fawcett, “When I Squeeze You with *Eisphorai*: Taxes and Tax Policy in Classical Athens,” *Hesperia: The Journal of the American School of Classical Studies at Athens* 85, no. 1 (January-March 2016): 188.

²⁰¹ Philonides 5=Pollux 9.29.

²⁰² Fawcett, “When I Squeeze You with *Eisphorai*,” 166.

²⁰³ S. Douglas Olson, “Athenaeus’ Aristophanes and the Problem of Reconstructing Lost Comedies,” in *Fragmente einer Geschichte der griechischen Komödie/Fragmentary History of Greek Comedy*, ed. Stylianos Chronopoulos & Christian Orth (Germany: Verlag Antike, 2015), 39-47.

fragments a significant place within it, the more likely it is to be wrong.”²⁰⁴ But in whatever way we may interpret the speaker of Philonides 4, it is clear from the fragment that the λογίζομαι activity is a bit shady, as the account will be rendered without charge and the matter will not be made public. This action is to be done behind closed doors.

The compounded form ἐκλογίζομαι occurs in Pherekrates 156:

εἰκῆ μ’ ἐπῆρας ὄντα τηλικουτονὶ
πολλοῖς ἐμαυτὸν ἐγκυλῖσαι πράγμασιν.
ἐγὼ γὰρ, ὦνδρες, ἠνίκ’ ἦν νεώτερος,
ἐδόκουν μὲν ἐφρόνουν δ’ οὐδέν, ἀλλὰ πάντα μοι
κατὰ χειρὸς ἦν τὰ πράγματ’ ἐνθυμουμένω·
νῦν δ’ ἄρτι μοι τὸ γῆρας ἐντίθησι νοῦν,
<καὶ> κατὰ μίτον τὰ πράγματ’ ἐκλογίζομαι.²⁰⁵

You pushed me, when I was that young, to get myself wrapped up in many affairs, but to no avail. For when I was younger, o men, I would think, yet I would have no good thoughts; instead, I would muse to myself with all the affairs at hand. But just recently my old age put a mind in me, and I go over (ἐκλογίζομαι) every affair with a fine-tooth comb.

The play to which this fragment is attributed, *Kheiron*, is very confusing considering the variety of topics, subjects, and characters included in its fragments,²⁰⁶ but Music seems to have been a major character. This does not help much with the above fragment, which clearly deals with an old man and politics. Looking at the fragment in isolation makes it clear, however, that the ἐκλογίζομαι shows a drastic change of mind and attitude: while the man in his youth was absentminded (literally), his old age has given him the mental ability to “over-account” the affairs with a more rigid, no-nonsense approach. Children do not ἐκλογίζομαι. This fragment

²⁰⁴ Ibid., 48.

²⁰⁵ Pherekrates 156=Stobaeus 4.50b.46.

²⁰⁶ Ian C. Storey, *Fragments of Old Comedy: Volume II, Diopethes to Pherekrates* (Cambridge: Harvard University Press, 2011), 494-497.

could be related to the concept of πολυπραγμοσύνη (“the quality of doing many things”, i.e. “meddlesomeness”), if it was spoken by someone similar to Philokleon in Aristophanes’s *Wasps*;²⁰⁷ if this were the case, the ἐκλογίζομαι would have a negative connotation, contrary to what we saw with most of λογίζομαι’s cognates in Aristophanes. ἐκλογίζομαι here does not necessarily denote calculation, but if the context were political affairs, it would seem likely that it does.

λογιστής appears in Eupolis 239 and Adespota 116:

ἄνδρες λογισταὶ τῶν ὑπευθύνων χορῶν.²⁰⁸

Men, reckoners (λογισταὶ) of the choruses under audit.

φροντιστὰ καὶ λογιστὰ²⁰⁹

o thinker and reckoner (λογιστὰ)²¹⁰

Both of these fragments appear to be isolated vocative phrases with no context. The Eupolis fragment likely refers to audience members, as they would be the ones who judge the choruses at the Dionysia and Lenaia festivals, but the anonymous fragment is impossible to contextualize further; it is not even clear whether we are to take the φροντιστὰ and the λογιστὰ as one and the same person or two different people. Harpocration cites Eupolis as part of an explanation of λογισταί, which he says τὰς εὐθύνας τῶν διωκημένων ἐκλογίζονται (“go over the accounts of those who kept house”), so to Harpocration at least there is a clear tie between λογιστής and λογίζομαι. In referring to the audience as λογισταί of the choruses, this fragment draws a link between auditing accounts and judging choruses, presumably because of the intense scrutiny which goes into each activity. In the case of a λογιστής, that scrutiny would come from close examination and verification of calculations, so perhaps this is drawing a parallel between

²⁰⁷ πολυπραγμοσύνη is a theme in many of Aristophanes’s plays. See Anton Bierl, “Die Dialektik von πολυπραγμοσύνη und ἀπραγμοσύνη. Die athenische Demokratie in den Komödien des Aristophanes und in Platons *Politeia*,” in *Der Vieltuer und die Demokratie: Politische und philosophische Aspekte von Allotio- und Polypragmosyne*, ed. Christine Abbt and Nahyan Niazi (Basel: Colmena, 2017), 36-43.

²⁰⁸ Eupolis 239=Harpocration p. 194.7.

²⁰⁹ Adespota 116=Athenaeus 401b.

²¹⁰ Translation is nearly identical to Storey’s.

judging a chorus and verifying calculations. φροντιστής is used of Sokrates in *Clouds*,²¹¹ but that by no means implies that this instance is of context or tone similar to that usage. If we are to take the φροντιστά and the λογιστά as the same person, that would show a link between thinking and calculating, but any further speculation would be even more of a stretch. From these occurrences of λογιστής, it is not clear whether we are to consider it a positive or negative (or even neutral) role, but some relation to calculation is not too far of a reach.

In a similar vein to λογιστής, ἀλόγιον appears in another Eupolis fragment:

καὶ γὰρ αἰσχρὸν ἀλογίου 'στ' ὀφλεῖν.²¹²

For it's shameful to owe money for improper bookkeeping (ἀλογίου).

A charge of ἀλόγιον would perhaps be best levelled by a λογιστής, but from this fragment alone, which is not attributed to any specific Eupolis comedy, it is impossible to tell who would be the leveler in this context. Photius's reason for citing it also provides no help, as he cites it as an instance of a neuter noun ending in -ιον. If it is meant as a serious statement, it would show that there is a degree of shame in not keeping proper financial accounts, meaning that there is some type of societal pressure to learn and to become sufficiently adept at record-keeping. Like the reference to λογιστής in Eupolis 239, it would not be controversial to say that there is a connection to calculation with this instance of ἀλόγιον.

Finally, the adverb ἀνεκλογίστως appears in Pherekrates 152:

εἴτ' ἐκεραμεύσαντο τοῖς μὲν ἀνδράσιν ποτήρια
πλατέα, τοίχους οὐκ ἔχοντ' ἀλλ' αὐτὸ τοῦδαφος μόνον,
κούχλι χωροῦντ' οὐδὲ κόγχην, ἐμπερῆ γευστηρίοις·
σφίσι δέ <γ> αὐταῖσιν βαθείας κύλικας ὥσπερ ὀλκάδας
οἶναγωγούς, περιφερεῖς, λεπτάς, μέσας γαστροῖδας,
οὐκ ἀβούλως, ἀλλὰ πόρρωθεν κατεσκευασμένοι

²¹¹ Aristophanes, *Clouds* 266.

²¹² Eupolis 377=Photius (z) α 2664.

αὔθ', ὅπως ἀνεκλογίστως πλεῖστος οἶνος ἐκποθῆ.
εἶθ' ὅταν τὸν οἶνον αὐτὰς αἰτιώμεθ' ἐκπιεῖν,
λοιδοροῦνται κώμνύουσι μὴ ἴκπιεῖν ἀλλ' ἢ μίαν.
ἢ δὲ κρείττων ἢ μί' ἐστὶ χιλίων ποτηρίων.²¹³

And for the men they (feminine) had crafted flat drinking cups, having no walls, just the bottom itself, and not even containing a shell-full, similar to tasting-cups. But for themselves they had crafted deep *kylikes*, like huge wine-carrying ships, completely round, delicate, like a paunch in the middle, and they had them prepared with every consideration taken into account, so that the most wine could go down the hatch without keeping track (ἀνεκλογίστως). Then whenever we accuse them of hitting the wine, they rail at us and swear that they won't drink but one. But their "one" is bigger than a thousand drinking cups.

This is clearly a riff on the well-attested comic stereotype of women as heavy and uncontrollable drinkers, and in fact Athenaeus quotes this to support the claim that women use large drinking vessels. One interesting aspect of this use of a cognate of λογίζομαι is that keeping track of drinks would presumably be a matter of counting, which might have suggested a cognate of ἀριθμέω. Not only is it a cognate of λογίζομαι, but it is prefixed with an intensifying ἐκ- and then negated with an alpha-privative: keeping track of drinks is apparently much more than just a matter of counting. With this complex adverb the speaker of this fragment asserts that counting after drinking so much is no longer a simple activity; rather, it takes a significant amount of cognition to figure out how many drinks they have had.²¹⁴ While women here appear clever and promethean in how they have arranged their drinking paraphernalia, the misogyny of the passage makes it clear that this is not a good thing from the speaker's point of view, and in fact the inclusion of ἀνεκλογίστως could imply that the speaker thinks that women could barely count with their wits about them, hence why it becomes so hard for them after getting drunk. Despite

²¹³ Pherekrates 152=Athenaeus 481b.

²¹⁴ The Confused Math Lady meme comes to mind as a great comparison here.

the misogyny, there is reference to number manipulation here. The other point to note with this instance of a cognate of λογίζομαι is that the adverb is denoting an unwillingness to *perform* the calculation of how many drinks they have had. By drinking ἀνεκλογίστως, the women here no longer perform the calculation for their inquisitive male counterparts, instead just simply saying “one”.

Shifting gears, cognates of ἀριθμέω appear in five fragments. Of these, three derive from the verb form itself (ἀριθμήσεις, ἀριθμεῖν, ἀμιθρεῖν), and two are forms of the related adjective ἀριθμητός. Two of the three verb forms of ἀριθμέω are unequivocally referring to the action of counting:

ἀπὸ ποτέρου τὸν καῦνον ἀριθμήσεις;²¹⁵

From which will you count (ἀριθμήσεις) the lots?²¹⁶

ἀριθμεῖν θεατὰς ψαμμακοσίους²¹⁷

to count (ἀριθμεῖν) the thou-sands of spectators

To the scholiasts, these fragments were both more notable for their strange vocabulary (καῦνον and ψαμμακοσίους) than their uses of ἀριθμέω. What is remarkable about the first fragment is that it is the only instance of ἀριθμέω in Old Comedy (including Aristophanes) in the second person, denoting an explicitly interpersonal activity. While the instances of it in the third person and the infinitive could also involve interpersonal activity, this is the only instance of a potentially performed count on stage between two characters. Unfortunately we do not have context for this specific line, even though we do know a bit about Kratinos’s *Pytinē* (“*Wine-Flask*”), so we cannot say for certain who was drawing lots to be counted and why. The second fragment (from Eupolis’s *Khrysoun Genos*, or *Golden Race*) well pre-dates the famous work of Archimedes (*Sand-Reckoner*), so clearly we cannot link the two in Eupolis’s time. But, as we will see again in the fragments containing ἀριθμητός, this use of ἀριθμέω occurs with the notion

²¹⁵ Kratinos 207=Scholium to Aristophanes’s *Peace* 1081.

²¹⁶ Nearly identical to Storey’s translation.

²¹⁷ Eupolis 308=Scholium to Aristophanes’s *Acharnians* 3a.

of uncountability (although perhaps not to Archimedes), as implied by ψαμμακοσίους (literally “sand-hundred”). The remaining fragment from the verb ἀριθμέω consists of only the word ἀμθρεῖν, which is explained as a mispronunciation of ἀριθμεῖν.²¹⁸ The possibilities for the metathesis of the ρ and the μ are almost limitless. Could it have been a baby speaking (where metathesis is common)? Could it have been due to a speech impediment like that of Alcibiades (made fun of in *Wasps*)?²¹⁹ Could it be a mockery of a non-Greek accent of Greek, like those made fun of in *Acharnians*?²²⁰ Or perhaps mocking a “sociolect,” as Colvin suggests Platon 183 mocks?²²¹ Could it have just been an error that was then assumed to be canon and not corrected by later scribes? Each of these possibilities could be the reality, but without anything more than the single word we have no way to confirm any of them. Accordingly, we adopt the view of Ewen Bowie here: “In this sort of question...one ought not to expect to be able to establish the truth of a hypothesis, though it may sometimes be possible to falsify one.”²²²

The two fragments with forms of ἀριθμητός contain quite similar uses of the adjective:

κρανία δισσὰ φορεῖν, ὀφθαλμοὶ δ’ οὐκ ἀριθματοὶ²²³

...[that it?] carries heads in twain, but [its?] eyes are not numerable
(ἀριθματοί)

τὸν πέπλον δὲ τοῦτον

ἔλκουσ’ ὄνεύοντες τοπέιους ἄνδρες ἀναρίθητοι
εἰς ἄκρον ὥσπερ ἰστίον τὸν ἰστόν.²²⁴

²¹⁸ Nikokhares 25=Photius 8 (z) α 1200.

²¹⁹ Aristophanes, *Wasps* 42-46.

²²⁰ Aristophanes, *Acharnians* 104.

²²¹ Stephen Colvin, “The Language of Non-Athenians in Old Comedy,” in *The Rivals of Aristophanes: Studies in Athenian Old Comedy*, ed. David Harvey and John Wilkins (Swansea: Classical Press of Wales, 2000), 290.

²²² Ewen Bowie, “Early Greek Iambic Poetry: The Importance of Narrative,” in *Iambic Ideas: Essays on a Poetic Tradition from Archaic Greece to the Late Roman Empire*, ed. Alberto Cavazzere, Antonio Aloni, & Alessandro Barchiesi (Oxford: Rowman & Littlefield Publishers, 2001), 25-26.

²²³ Kratinos 161=Hephaestion, *Handbook*, 1.9.

²²⁴ Strattis 31=Harporation p. 290.5.

Innumerable (ἀναρίθμητοι) men hauling ropes drag the mantle there up to the top [of the statue of Athena] like a sail up to the mast.

Both of these fragments use the adjective ἀριθμητός to emphasize a large number of something by negation (the first by the word οὐκ, the second by alpha-privative). The first fragment comes from Kratinos's *Panoptai*, a title which provides the potential for either a chorus of Argos Panoptes-esque monsters, a character based on Argos Panoptes, or an appearance of the mythological giant himself. Perhaps the costuming for such a chorus or character could not be seen in detail, so another character here is describing it for the audience; or, perhaps even more likely, a character is describing what they saw (an Argos-character) to another character. Either way, the fact that the eyes are οὐκ ἀριθματοί draws attention to the unnaturalness of the creature being described. Also note that ἀριθματοί has been retained because it is suspected to be a Doric pronunciation, so perhaps a non-Athenian is speaking the line. The second fragment has similar effect: the men are innumerable, which draws attention to the enormous feat of pulling the πέπλος up onto the statue of Athena for the Panathenaia festival. Since this fragment is more than one line, it is worth remarking on the simile to pulling a sail up to mast: Athens was well known for its naval power, and connecting an innumerable crowd of strong men to that power certainly sounds like a propagandistic end. In sum, three of these five fragments use the concept of counting to emphasize how large a quantity of something is.

Not included in the above fragments is this fragment, attributed to Epikharmos by its preserver, Clement of Alexandria, but deemed spurious by Kassel and Austin:

ὁ βίος ἀνθρώποις λογισμοῦ κἀριθμοῦ δεῖται πάνυ.
ζῶμεν ἀριθμῶ καὶ λογισμῶ· ταῦτα γὰρ σώζει βροτούς

ὁ λόγος ἀνθρώπους κυβερνᾷ κατὰ τρόπον σώζει τ' ἀεί.
ἔστιν ἀνθρώπῳ λογισμός, ἔστι καὶ θεῖος λόγος.
U — ἀνθρώπῳ πέφυκε περὶ βίου καταστροφάς·
ὁ δέ γε τὰς τέχνας ἅπασι συνέπεται θεῖος λόγος,
ἐκδιδάσκων αὐτὸς αὐτοὺς ὅτι ποιεῖν δεῖ συμφέρον.

οὐ γὰρ ἄνθρωπος τέχνην εὖρ', ὁ δὲ θεὸς ταύταν φέρει·
ὁ δὲ γε τάνθρώπου {λόγος} πέφυκεν ἀπὸ γε τοῦ θεοῦ λόγου²²⁵

Life for humans is entirely dependent on calculation (λογισμοῦ) and number (ἀριθμοῦ). We live by number (ἀριθμῶ) and by calculation (λογισμῶ). For these things save mortals.

Reason (λόγος) steers humans fittingly and always saves them. There is for humankind calculation (λογισμός), and for the divine there is reason (λόγος). ...[it?] grew in humankind around the end of life, but it, divine reason, tends to skills for all, itself explaining that they ought to make a profit. For humankind did not discover skill, the god brings it to them. And human reason grew from divine reason.

While this may be considered spurious, it seems still worth mentioning as Clement of Alexandria seemed sure that it was authentic (unless of course it is entirely his invention). According to Clement, this fragment is part of a comedy called *Politeia*, which he attributes to Epikharmos, but Cassio seems to attribute this play to a flutist named Khrysogonos, placing it still in the fifth century BCE.²²⁶ From the “clear emphasis on ἀριθμός and λογισμός” at the beginning of the passage, Cassio thinks that the author (in his view, Khrysogonos) is portrayed as a Pythagorean,²²⁷ and this is certainly possible, but it is a bit of a stretch to assume so much about an uncertain author from this one fragment. This interpretation also seems to ignore the fact that this is ostensibly from a play, not its author speaking directly, so this could just as easily be the view of the character, not necessarily the author. Whoever the author may be, if indeed it does date to the fifth century BCE, the almost dramatic assertion that ἀριθμός and λογισμός “save mortals” is in stark contrast to most of the instances of these words’ cognates in the rest of the sources we have examined. In Aristophanes ἀριθμός seems certainly negative, while in the other

²²⁵ Pseudepikharmos 240=Clement of Alexandria, *Miscellanies* 5.118.1.

²²⁶ Albio Cesare Cassio, “Two Studies on Epicharmus and His Influence,” in *Harvard Studies in Classical Philology* vol. 89 (1985), 48-49.

²²⁷ *Ibid.*, 49.

Old Comic authors above counting did not seem to serve any purpose except when it could not be done. λογισμός has a slightly more positive reputation than ἀριθμός, but certainly not to the extent of it saving lives. Would that the author were Epikharmos for certain, as then this would provide an interesting contrast between Sicilian and Athenian comedy, which are known to have influenced each other.²²⁸

Searching the fragments for examples of μετρέω and references to μέτρα yields only five fragments, two of which are a bit dubious. Philyllios has this fragment preserved:

σοὶ μὲν οὖν τήνδ', ἀμφορεῦ,
δίδωμι τιμήν, πρῶτα μὲν τοῦτ' αὐτ' ἔχειν
ὄνομα μετρητὴν μετριότητος οὐνεκα.²²⁹

Then to you, *Amphoreus*, I give this honor, that you have first and foremost this very name, “measurer” (μετρητὴν), because of your moderation (μετριότητος).

This comes from a comedy called *The Twelfth* (Δωδεκάτη), which Hesychius lists as a festival in Athens also known as the Khoes, the second day of the Anthesteria three-day festival.²³⁰ Since this festival had to do with wine, it would be fitting for this play to have this connotation in light of this fragment, the only one attributed securely to this play. The pun between μετρητὴν and μετριότητος is difficult to render in English, but the joke has potential to be twofold: in addition to the pun, depending on the size of the *amphoreus*, the reference to its μετριότης could have been a visual gag (e.g. an oversized vessel would hardly be moderate, or a miniature vessel would be overly moderate). The word μετριότης itself is quite rare, but it does appear in Thucydides’s *Peloponnesian War*, where the Corinthians think that it would be shameful for them to force the Korkyraians’ μετριότης, even if the Corinthians were in the wrong.²³¹ From this context it seems that μετριότης is something enforceable, but it is ill-advised for someone to enforce it. Seeing as the fragment highlights the μετριότης linked to the measurement μετρητής,

²²⁸ Ibid., 39-43.

²²⁹ Philyllios 6=Pollux 10.70.

²³⁰ Hesychius, *Lexicon* δ 2708.

²³¹ Thucydides, *Peloponnesian War* 1.38.

a μετρητής must naturally bring to mind enforcing μετριότης to some extent, which could carry negative connotations if taken the same way as the Corinthians in Thucydides’s reported speech. The measurement μετρητής is also preserved on an inscription on a Parian Marble, which explains that the prize for the first-place comic chorus was a basket of figs and a μετρητής of wine (ἄθλον ἐτέθη πρῶτον ἰσχάδω[ν] ἄρσιχο[ς] καὶ οἴνου με[τ]ρητής).²³² If this was something the audience was aware of, the Philyllios fragment above might have called the prize to mind, rather than remind them of the agora or other measuring contexts. Without more context for the fragment, however, we cannot say more than this.

Regarding types of μέτρα, we have part of a dialogue from a play by Strattis:

{A} τὰ δ’ ἄλφιθ’ ὑμῖν πῶς ἐπώλουν; {B} τετταρων
 δραχμῶν μάλιστα τὸν κόφινον. {A} τί λέγεις; μέτρῳ
 ἐχρῶντο κοφίνῳ; {B} † ἢ < > τοῦτ’ αὐθ’ ὅτι
 οἴνου κόφινος, δυνάμενος τρεῖς χοᾶς
 πυρρῶν ταῖς κοφίταις ταῦτα ταῦτα δυνάμενος †²³³

{A} And how were they selling barley to you?

{B} A *kophinos* for about four drachmai.

{A} What do you mean? They were using a *kophinos* as a measure?

{B} Or < > this very thing, that a *kophinos* of wine can hold three *khoes* and can hold the same amount as *kophinoi* of grain.

The “they” in this fragment are the Boiotians, meaning speaker B probably went to Boiotia and is reporting back that they used the same measure (a *kophinos*) for both wet and dry measurement. To an Athenian, then, there must be a sense that some measures are used only for specific things, although it should not have been a surprise that other Greeks used one measure for both wet and dry measurement, as the Athenian *kotylē* was just such a measure found in what

²³² Marmor Parium 239 A 39.

²³³ Strattis 14=Pollux 4.168-169.

are now called σηκώματα, or measuring tables, from the Hellenistic period especially.²³⁴ The surprise featured here over a *kophinos* being used as a measure is especially striking when considering how close Attica and Boiotia are geographically: it implies that some Athenians must have been unaware of the customs of their geographical neighbors. Perhaps knowledge of measures used outside Athens was specialist knowledge.

In addition to the two fragments above, this short fragment from a comedy of Theopompos is preserved:

ἢ μετάδος ἢ μέτρησον ἢ τιμὴν λαβέ.²³⁵

Either give a share, measure out (μέτρησον), or pay the price.

This scholiast cited this line as another instance where μέτρησον is used as a stand-in for δάνεισον, a more technical word for lending money. However, the line of *Acharnians* on which the scholiast is commenting makes sense also in the literal sense of measuring out, as in line 1021 a farmer is asking Dikaiopolis to μέτρησον some peace for him, which is contained in a wineskin. In this light I have kept the sense of “measure out” rather than “lend money” in my translation of this fragment, but without more context for this fragment it is impossible to infer anything about how this “measuring out” would relate to the other, alternative commands. What can be said is that linking the act of lending money to measuring with this word could imply a (potentially earlier) form of lending that involved actual measurement, rather than a counting of coinage. This might have involved measuring out a quantity of metal from an ingot, or measuring out a loan of grain to be paid back later. In any case, the existence of this fragment shows that the μέτρησον in *Acharnians* 1021 may not just be a reference to the wineskin of peace, and that this instance of μέτρησον in the fragment may not just be a reference to money lending.

The remaining two fragments are difficult to interpret. One, Strattis 62, has been emended by Capps to read μετρεῖ rather than μάττει, rendering the fragment thus:

²³⁴ Carla Cioffi, “Documenting, measuring and integrating *sekomata*: An example from Naxos,” *Dialogues d’histoire ancienne* 12, issue 12 (2014): 46, 52-55.

²³⁵ Theopompos 27=Scholium to Aristophanes’s *Acharnians* 1021a.

ὁ δέ τις ψυκτῆρ', ὁ δέ τις κύαθον
χαλκοῦν κλέψας ἀπορῶν κεῖται,
κοτύλη δ' ἀνὰ χοίνικα μετρεῖ.²³⁶

Someone who stole a wine-cooler or someone who stole a bronze ladle still remains at a loss, a *kotylē* measures up (ἀνὰ...μετρεῖ) a *khoinix*.

Without Capps's emendation, "a *kotylē* wipes off (μάττει) a *khoinix*" is obscure, and the fragment with the emendation is not very insightful, as it is already established that four *kotylai* make one *khoinix*. Perhaps the joke pivots on the physical instrument which measures a *kotylē*, i.e. the cup, as opposed to the wine-cooler and the ladle which both cannot be used to measure out a *khoinix*. Thus anyone who did not steal a *kotylē* would be at a loss when trying to measure a *khoinix*. But without more context even this explanation of this fragment remains a bit cryptic. The last fragment is very corrupt, but it calls Leotrophides, a general and *khoregos* known for being pale and skinny, a τρίμετρος.²³⁷ τρίμετρος, in the first line, generally refers to a poetic measure, not a volume measure, so the sense here is obscure, and the fact that the fragment is preserved mainly for the descriptors in the second line does not shed any more light. Seeing as the fragment paints a negative picture of Leotrophides, it would appear τρίμετρος is meant as another insult or jocular comparison, but beyond that we cannot say much.

In the whole corpus of Old Comic fragments, ἀστρονομία never occurs, but there are a few references to astronomical phenomena. Kratinos mentions Ursa Major in his comedy *Odysseuses*:

ἐπ' ἀριστερ' ἀεὶ τὴν Ἄρκτον ἔχων λάμπουσαν, ἕως ἂν ἐφεύρης.²³⁸

Keeping the shining Ursa Major on your left, until you find it.

²³⁶ Strattis 62=Athenaeus 502e.

²³⁷ Theopompos 25=Scholium to Aristophanes's *Birds* 1406.

²³⁸ Kratinos 144=Photius (z) α 2826.

Platonius claims that this play was a parody of Homer's *Odyssey*, so perhaps this was given as a direction for sea travel. Since Ursa Major is in the (approximate) north of the night sky, this direction would be to travel approximately east until finding the destination or the next landmark. Without more context, we cannot say for certain whether this direction would have been serious (since much of Odysseus's misfortunes seem to have brought him too far west) or deceptive (e.g. if Odysseus was west of the Italian peninsula, heading east would bring him to Italy, not Greece). However, this fragment does demonstrate that the audience in Kratinos's time, just before Aristophanes, would understand a practical use of astronomy, i.e. for navigation.

There are two other references to specific celestial phenomena:

πίνειν γὰρ αὐτὸν Πρωταγόρας ἐκέλευ', ἵνα
πρὸ τοῦ κυνὸς τὸν πνεύμον' ἔκπλυτον φορῆ.²³⁹

For Protagoras was telling him to drink so that he would have his
lung washed out before the Dog Star.

καί σε τῇ νουμηνία
ἀγαλματίοις ἀγαλοῦμεν ἀεὶ καὶ δάφνη.²⁴⁰

And on the new moon we will always bestow you with glories and
laurel.

Later the Eupolis fragment will be discussed further in relation to its reference to Protagoras, but for now we will note that in Hesiod's *Works and Days* the Dog Star was associated with heat and dryness.²⁴¹ Thus its reference here seems in line with those associations, since the goal of the drinking is to hydrate the lung, and accordingly the audience must have had this same association as Hesiod to some extent. The second fragment of Theopompos connects the new moon with presumably a religious rite, since ἀγάλλω is generally used for exulting deities. The reference to laurel suggests Apollo as the antecedent of the "you," and the absence of the moon would

²³⁹ Eupolis 158=Plutarch, *Table-Talk* 699a.

²⁴⁰ Theopompos 48=Photius (b, z) α 163.

²⁴¹ Hesiod, *Works and Days* 414-419, 582-588.

correspond to an absence of his sister, Artemis. Aside from this possible identification of the “you,” not much else can be determined; the fragment comes from a play titled *Penelope*, presumably the wife of Odysseus, but this does not help identify the speaker here. The above three fragments all show that the comic audience had some associations with observable celestial phenomena, which could mean that the practical side of astronomy was not completely rejected by the average Athenian.

References to weights and coinage became complicated for the later authors that preserved the fragments. Specifically, Pollux cites Alkaios 12 as an instance where he could not determine whether “talent” referred to worth or weight. Other fragments are cited to show that a specific word is used as a coin value in some contexts (e.g. Eupolis 123 in Pollux), or that it is used as a weight (e.g. Eupolis 270, also in Pollux). If not cited for these reasons, most of the other fragments which include coins are cited by Athenaeus because they reference a type of fish. However, one fragment is cited for a different reason:

χαλεπῶς ἂν οἰκήσαιμεν ἐν Βυζαντίῳ
ὅπου σιδαρέοισι † νομίσμασι †²⁴²

We’d hardly be able to live in Byzantium where [they use] iron coins.

This is cited in the scholia of *Clouds* as further evidence of Byzantium using iron coins. The fact that Byzantium’s use of iron coins was a running joke among multiple authors must mean that the audience considered their own silver coins to be superior, or at least thought that silver made more sense to be used for coinage. Much like the surprise at the Boiotians using a *kophinos* for wet and dry measurement, there is a sense here that some materials or objects have specific uses, and using them otherwise is funny.

Although little of it survives, one play by Pherekrates is said by Pollux to have been named *Krapataloi*, which took place in Hades.²⁴³ The title literally is a type of small fish, but in the play these fish are the currency of the underworld, which were further broken down into “crumbs”

²⁴² Platon Comicus 103=Scholium to Aristophanes’s *Clouds* 249b.

²⁴³ Pollux 9.83.

(ψωθία).²⁴⁴ Supposedly Aeschylus and potentially other literary characters appeared in the play, and Storey claims that it probably debuted before *Frogs*.²⁴⁵ If the convention of comedies being named after their choruses hold here, *Krapataloi* could have had a chorus of fish/currency that spoke to the audience. Considering the metrical similarities between Pherekrates 102 and choral passages in plays of Aristophanes, this fragment could very well be spoken by a chorus of *krapataloi*:

τοῖς δὲ κριταῖς
τοῖς νυνὶ κρίνουσι λέγω,
μὴ ἴπιορκεῖν μηδ' ἀδίκως
κρίνειν, ἢ νῆ τὸν φίλιον
μῦθον εἰς ὑμᾶς ἕτερον
Φερεκράτης λέξει πολὺ τού-
του κακηγορίστερον.²⁴⁶

And I say to the judges, those judging now, not to swear falsely
and not to judge unfairly, or by [Zeus,] the god of friendship,
Pherekrates will tell you another tale, one much more slanderous
than this one.

If this is indeed the chorus speaking, this brings a whole new meaning to “money talks”: the “money” of the underworld would be directly threatening the judges, ordering them to award Pherekrates the top prize. Anything else would be “unfair” (ἄδικος). It is hard to tell to what extent the currency aspect of the *krapataloi* played into this comedy, but perhaps there was at least an undercurrent of currency as a means of deception and influence.

References to taxes and the treasury are uncommon in the Old Comic fragments. However, Epikharmos relates comedy to fines thus:

{A} † ἐκ μὲν θυσίας θοίνα

²⁴⁴ Pherekrates 86=Athenaeus 646c.

²⁴⁵ Storey, *Fragments of Old Comedy II*, 459-461.

²⁴⁶ Pherekrates 102=Photius p. 647.22.

ἐκ δὲ θοΐνας πόσις ἐγένετο. {B} χαρίεν, ὥς γ' ἐμοὶ <δοκεῖ>.
{A} ἐκ δὲ πόσιος κῶμος, ἐκ κώμου δ' ἐγένεθ' ὑανία,
ἐκ δ' ὑανίας δίκαια, <'κ δίκας δ' ἐγένετο καταδίκαια>,
ἐκ δ' καταδίκας πέδαι τε καὶ σφαλὸς καὶ ζαμῖα²⁴⁷

{A} From sacrifice came feast, and from feast came drink.

{B} Smart, as it seems to me.

{A} And from drink revelry (κῶμος), from revelry came swinishness, from swinishness justice, <from justice came sentence>, and from sentence shackles and stocks and fines (ζαμῖα).

The accepted etymology of “comedy” (κωμῳδία) is from κῶμος (revelry) and ᾠδή (song/ode), so if both comedy and fines have κῶμος as a common ancestor, the two must be related. Admittedly, these ζαμῖαι are more punitive than tax-related fines, but the step from punitive fines to taxes is not too large of a jump. While Epikharmos was not Athenian, it is nevertheless true Athenian comedians have used their comedies to critique and to draw attention to taxes placed on Athenians. Among the remnants of Old Comedy, however, this is relatively rare. Four of the nine fragments which mention taxes are preserved specifically because they reference taxation. Aristomenes is said to have mentioned how enslaved people when released from their enslaved status had to pay the metic tax (μετοίκιον),²⁴⁸ while Eupolis references the harbor tax (ἐλλιμένιον):

ἐλλιμένιον δοῦναι πρὶν εἰσβῆναί σε δεῖ.²⁴⁹

You have to pay the harbor tax before getting on.

This line could fit into any number of jokes, so speculating about the context would be in vain. But according to Fawcett, Athens levied harbor taxes by the mid-420s BCE,²⁵⁰ putting this play

²⁴⁷ Epikharmos 146.

²⁴⁸ Aristomenes 16=Harpocration p. 204.4 Dindorf.

²⁴⁹ Eupolis 55=Pollux 9.30.

²⁵⁰ Fawcett, “When I Squeeze You with *Eisphorai*,” 159.

(*Autolykos*, which is securely dated to 420 BCE)²⁵¹ right after these taxes may have been introduced. Thus this line may have been a very contemporary stab at the recently imposed taxes. From the inclusion of specific taxes in jokes we can see that audience members would have knowledge of these taxes, perhaps even if they did not pay them themselves, and taxes could be employed to enhance a joke. Unfortunately, no actual fragments are preserved which reference the treasury, except two, which merely summarize plot points of two Eupolis plays rather than provide direct quotes from them.

Aside from Meton, who was discussed earlier, two other famous mathematical people appear in Old Comedy: Protagoras and Plato the philosopher. Protagoras appears in two fragments, both from Eupolis's play *Kolakes*:

ἔνδον μὲν ἐστὶ Πρωταγόρας ὁ Τήος
ὃς ἀλαζονεύεται μὲν ἀλιτήριος
περὶ τῶν μετεώρων, τὰ δὲ χαμᾶθεν ἐσθίει.²⁵²

And inside is Protagoras from Teia, who rattles on about what's above with something to hide, but he eats what's on the ground.

πίνειν γὰρ αὐτὸν Πρωταγόρας ἐκέλευ', ἵνα
πρὸ τοῦ κυνὸς τὸν πνεύμον' ἔκπλυτον φορῆ.²⁵³

For Protagoras was telling him to drink so that he would have his lung washed out before the Dog Star.

We know a fair bit about *Kolakes* from its fragments and testimonia. It seems to have involved the real Athenian Kallias, whose father Hipponikos had died shortly before the play debuted in 421 BCE. Having been left a large and lavish inheritance from his father, Kallias in the play spends enormous amounts of money, presumably attracting the chorus of *κόλακες*, those who

²⁵¹ Storey, *Eupolis*, 61-62.

²⁵² Eupolis 157=Diogenes Laertius 9.50 and Eustathius *On the Odyssey* p. 1547.52.

²⁵³ Eupolis 158=Plutarch, *Table-Talk* 699a.

mooch off of the wealthy to get by.²⁵⁴ The appearance of Protagoras in this play is, according to Athenaeus, chronologically very close to when Protagoras visited Athens, so once again we have a comedy referencing recent events in Athens.²⁵⁵ Whether Protagoras appeared just as a cameo (like Meton in *Birds*), a named chorus member, or even a full-fledged character in the play is not certain. Tylawsky takes Protagoras's appearance "inside" (ἔνδον) as evidence that he was indeed a moocher,²⁵⁶ while Storey takes Protagoras as a sort of "poltergeist" who ravages Kallias's household.²⁵⁷ However he appeared in the play, was Protagoras portrayed faithfully to reality? It is, of course, hard to say, but from these fragments it would seem that the stage Protagoras was potentially an expert in μετέωρα, eating, and anatomy. Of the surviving titles of his works, none seem to be about any of these topics.²⁵⁸ According to Plato's depiction of him as well as later authors, Protagoras seems to have been mainly interested in geometry,²⁵⁹ rhetoric and grammar,²⁶⁰ and potentially atheism,²⁶¹ so the topics brought up in these fragments do not seem to line up with later authors' understandings of Protagoras. This disconnect could be explained by the brevity of Protagoras's visit to Athens, which would mean the average Athenian could not interact with him all that much, if at all, and since this comedy debuted shortly after his visit the comedy could not possibly have depicted him the same way that later authors who had access to his works for years or even centuries could. Nevertheless, the information about Protagoras contained in these two fragments seems to paint a heavily distorted picture in relation to later sources. Protagoras here is a corrupter of the youth, much like Sokrates in *Clouds* was, and he finds his way into their coin purses and pantries.

Only one fragment in Old Comedy refers to Plato the philosopher:

ἔν γάρ ἐστιν οὐδὲ ἔν,
τὼ δὲ δύο μόλις ἔν ἐστιν, ὡς φησιν Πλάτων.²⁶²

²⁵⁴ Storey, *Eupolis*, 180-184.

²⁵⁵ Athenaeus 218c. See also Storey, *Eupolis*, 184.

²⁵⁶ Elizabeth Ivory Tylawsky, *Saturio's Inheritance: The Greek Ancestry of the Roman Comic Parasite* (New York: Peter Lang Publishing, 2002), 44

²⁵⁷ Storey, *Eupolis*, 187.

²⁵⁸ Diogenes Laertius 9.55.

²⁵⁹ Aristotle, *Metaphysics* B2 998a2-4; Philodemus, *De Poematis* (P.Herc. 1676).

²⁶⁰ Plato, *Cratylus* 391c; Plato, *Phaedrus* 267b-c; Aristotle, *Rhetoric* 3.5 1407b7-8.

²⁶¹ Diogenes Laertius 9.51.

²⁶² Theopompos 16=Diogenes Laertius 3.26.

For one isn't even one. Two is just one, as Plato says.

Scholars have taken this as a reference to Plato's *Phaedo*:

οὐκ ἀποδέχομαι ἑμαυτοῦ οὐδὲ ὡς ἐπειδὴν ἐνί τις προσθῆ ἕν, ἢ τὸ
ἕν ᾧ προσετέθη δύο γέγονεν, ἢ τὸ προστεθὲν, ἢ τὸ προστεθὲν καὶ
ᾧ προσετέθη διὰ τὴν πρόσθεσιν τοῦ ἑτέρου τῷ ἑτέρῳ δύο
ἐγένετο.²⁶³

I don't even understand my own train of thought when someone adds one to one if it the one to which it is added that became two, or the one that was added, or the one that was added and the one to which it was added became two through the addition of one to the other.

If Theopompos really was referring to the *Phaedo*, this would be a remarkable fragment, as it would assume a significant portion of the audience would have read at least this work of Plato. If average Athenians were reading Plato's works, the Academy may not have been as elite as it has been portrayed. The *Phaedo* itself may have been written in the late 380s BCE,²⁶⁴ and this play of Theopompos may have debuted around 380 BCE or after,²⁶⁵ so chronologically this would be a tight turnaround from publication to parody. However, a tight turnaround would be well in line with other references discussed above (the short time between harbor taxes being levied and their appearance in Eupolis's *Autolykos*, or between Protagoras's visit and his appearance in Eupolis's *Kolakes*). Alternatively it is equally likely that Plato had given a lecture related to this *Phaedo* passage, and word had spread throughout Athens of "one not being one." In this case the ideas and thoughts being produced in the Academy would have been filtering down into the population, and not necessarily accurately. Whatever the inspiration for this line may be, it nevertheless demonstrates that the audience could not just recognize Plato the philosopher, but differentiate him from Plato the comedian by a reference to his work.

²⁶³ Plato, *Phaedo* 96e-97a.

²⁶⁴ David Ross, *Plato's Theory of Ideas* (Oxford: Oxford University Press, 1951), 10.

²⁶⁵ Storey, *Fragments of Old Comedy III*, 325-327.

Lastly, the fragments preserve a fair number of ratios and numbers in the context of wine and gambling. That many of these are preserved is not particularly surprising, as Athenaeus devotes a section of the *Deipnosophists* to wine ratios, but I have singled them out here as further evidence of numbers in Old Comedy. While no surviving comedy references geometric ratios, not even in *Birds* with Meton, 11 fragments reference wine ratios. These wine ratios come in the form of [numeral] καὶ [numeral] (e.g. πέντε καὶ δύο, “five and two”),²⁶⁶ or the special case of one-to-one, ἴσον ἴσῳ.²⁶⁷ Notably, these are not the form that Euclid uses for ratios in the *Elements*, which are explicitly labelled as λόγοι and are generally of the form τὸ [letter] πρὸς τὸ [letter].²⁶⁸ Although the difference in these forms could be attributed to the period of time between these works, it seems more likely that the difference in forms between wine ratios and the geometric ratios in Euclid’s *Elements* can be attributed to the difference between their contexts; the fact that the wine ratios are never referred to as λόγοι (not even by Athenaeus, who refers to them as κράσεις) points even towards the two “ratios” being seen as two completely different concepts. While Euclid’s λόγοι employ a preposition (πρὸς) to denote their comparisons, wine ratios in Old Comedy simply use the conjunction καί, which denotes the mixing of the ingredients (water and wine). The exception of course is ἴσον ἴσῳ, which uses a dative of reference (“equal to equal”), but this still does not have the same comparative emphasis of a preposition. Thus there must be a fundamental difference between wine ratios in Old Comedy and geometric ratios in Euclid. Nevertheless, the juxtaposition of the two numbers with καί does convey information, namely the strength of the mixed wine. Both numbers are essential to determining the strength, as is shown in Pherekrates 76:

{A} ἄποτος, ὧ Γλύκη.
 {Γλύκη} ὕδαρῆ ἑνέχεν σοι; {A} παντάπασι μὲν οὖν ὕδωρ.
 {Γλ} τί εἰργασῶ; πῶς ὧ κατάρατε <δ’> ἐνέχεας;
 {B} δύο ὕδατος, ὧ μάμμη. {Γλ} τί δ’ οἴνου; {B} τέτταρας.
 {Γλ} ἔρρ’ ἐς κόρακας. βατράχοισιν οἰνοχοεῖν σ’ ἔδει.²⁶⁹

²⁶⁶ Ameipsias 4=Athenaeus 426ef.

²⁶⁷ Arkhippos 2=Athenaeus 426b.

²⁶⁸ E.g. Euclid, *Elements* V Proposition 4.

²⁶⁹ Pherekrates 76=Athenaeus 430e.

{A} It's undrinkable, Glykē. {Glykē} Do you have too much water in yours? {A} It's entirely water! {Gl.} What am I to do? How did you fill [the *krater*], you wretch? {B} Two of water, mum. {Gl.} What of wine? {B} Four. {Gl.} Rush off to hell! You might as well have poured a glass for the frogs!

Clearly the wine ratio here is unsatisfactory, but Glykē only realizes how terrible a mix the mixer made once she knows both numbers of the ratio. These may not be Euclid's ratios, but they still convey information as an inseparable pairing of numbers.

Thus we have exhausted the corpus of Old Comedy for all mathematical references. What remains is to synthesize these findings and to ask what it all means.

6. What Does It All Mean?

We have to this point seen a great variety of mathematical topics at play in Aristophanes's works and the Old Comic Fragments: astronomy, calculation, counting, geometry, volume measurement, and ratios all appear to some extent in these works. Now we can turn to some of the questions raised earlier: Is mathematics mentioned in order to critique math itself, or those who use and misuse it? Was Plato's definition of μαθήματα at all valid in Athenian comedy? Was the audience expected to view mathematics in a positive or negative light? Was mathematics portrayed as a necessary pursuit? To what extent were comic writers aware of the works of mathematical writers? While these questions still cannot be answered completely, they can at least be partially answered using what remains of Old Comedy.

Seeing as Aristophanes's works are by far the best preserved, they appear to be the best place to start when answering these questions, although the fragmentary authors are by no means trivial. Aristophanes seems never to critique calculation and counting specifically as faulty pursuits or inherently useless skills, but rather those who use and misuse them. However, the critique of these people is rarely focused on a specific person for misleading through mathematics, as opposed to the well-studied attacks on specific politicians that contributed to the incomprehensibility of Old Comedy just a few centuries after its heyday.²⁷⁰ The only instance where a named historical figure is criticized for misusing calculation is Sokrates in *Clouds*, when the learner explains how he measured the distance a flea can jump according to its own feet,²⁷¹ and this is certainly not the only thing for which Aristophanes makes fun of this exaggerated Sokrates. In other instances, groups of people or characters of the play itself are criticized instead (e.g. the chorus leader's chastising soldiers for counting up the enemy soldiers before heading into battle in *Knights*,²⁷² Strepsiades's calling the audience an ἀριθμός disparagingly in

²⁷⁰ Plutarch, *Quaestiones Convivales*, 711f-712a, esp. 712a.4-11:

ἔτι δ' ὥσπερ ἐν τοῖς ἡγεμονικοῖς δεῖπνοις ἐκάστω παρέστηκε τῶν κατακειμένων οἰνοχόος, οὕτω δεήσει γραμματικὸν ἐκάστω τὸ καθ' ἕκαστον ἐξηγεῖσθαι, τίς ὁ Λαισποδίας παρ' Εὐπόλιδι καὶ ὁ Κινησίας παρὰ Πλάτωνι καὶ ὁ Λάμπων παρὰ Κρατίνῳ, καὶ τῶν κωμωδομένων ἕκαστος, ὥστε γραμματοδιδασκαλεῖον ἡμῖν γενέσθαι τὸ συμπόσιον ἢ κωφὰ καὶ ἄσημα τὰ σκώμματα διαφέρεσθαι.

And yet, just as at the leaders' feasts a wine-pourer was stood beside each of the diners, so will each diner need a grammar to take them through each [work], what is Eupolis's *Laispodias* and Plato's *Kinesias* and Kratinos's *Lampon*, and each of those made fun of, so that the symposium becomes a literature lesson for us, or the jokes become dull and obscure in being taken apart.

²⁷¹ Aristophanes, *Clouds*, 143-152.

²⁷² Aristophanes, *Knights*, 565-573.

Clouds,²⁷³ Chremylos’s suspecting Blepsidemos would falsify accounts in *Wealth*²⁷⁴). So while many political positions and activities (including attending the assembly, like Dikaiopolis in *Acharnians*²⁷⁵) would have required calculation and counting abilities, Aristophanes does not seem to attack any specific person for having such abilities. Furthermore, while Aristophanes has characters chastise other parties *for* calculation, he also has characters chastise other parties *by* calculation (e.g. Bdelykleon telling Philokleon in *Wasps* to λόγισαι on his fingers and calculating the difference between Athens’ tribute and expenses,²⁷⁶ Dionysos counting how many times Aeschylus uses the same line in *Frogs*²⁷⁷), thus calculation can be used both *by* and *against* those in power. In this light, it seems that Aristophanes does not necessarily critique either mathematics itself or those who use it, but rather only those who use it frivolously or even maliciously without, for the most part, calling out historical figures specifically.

Calculation, then, is not restricted to any given class or type of people, but rather some level of calculation ability is assumed for most people. This would appear to include women as well as men, and enslaved as well as free people, if we assume the duties involved with the verb ταμειύω include calculation. This verb is used of both women²⁷⁸ and enslaved men²⁷⁹, and while these could be merely comical associations, we have no reason to discount these people from calculation abilities, as Plato seems to in his *Laws*.²⁸⁰ Moreover, we can assert with near certainty that the subject areas which constitute μαθήματα in Aristophanic comedy are not limited to the three which the later Plato claims constitute μαθήματα (namely, calculation, geometry, and astronomy).²⁸¹ From *Clouds* it is clear that poetic measures and rhythms, word analysis, and rhetoric are also μαθήματα, as peddled by Sokrates to Strepsiades in the Thought-shop,²⁸² and *Birds* offers the lesson of building high walls and big ships as a μάθημα.²⁸³ It is possible that the inclusions of poetic measures and word analysis as μαθήματα were jokes in themselves that then compounded later jokes (e.g. Strepsiades’s mistaking poetic measures for literal measures of

²⁷³ Aristophanes, *Clouds*, 1201-1203.

²⁷⁴ Aristophanes, *Wealth*, 380-381.

²⁷⁵ Aristophanes, *Acharnians*, 28-36.

²⁷⁶ Aristophanes, *Wasps*, 656-663.

²⁷⁷ Aristophanes, *Frogs*, 1263.

²⁷⁸ Aristophanes, *Ekklesiazousai*, 211-212; *Lysistrata*, 488-497; *Thesmophoriazousai*, 418-421.

²⁷⁹ Aristophanes, *Knights*, 942-959.

²⁸⁰ Plato, *Laws*, 817e-818a.

²⁸¹ Ibid.

²⁸² Aristophanes, *Clouds*, 636-699, 737-790.

²⁸³ Aristophanes, *Birds*, 375-380.

volume,²⁸⁴ Sokrates's mistaking the vocative form of the name Ἀμυνίας as a feminine form and Strepsiades's thinking that a feminine name is fitting for his cowardice²⁸⁵), so perhaps these were not seriously considered μαθήματα by the actual audience. Nevertheless, considering the audience was expected to at least entertain these subjects as μαθήματα for later jokes to land, and that calculation was most likely not restricted to "free men", it is probable that Plato's definition of μαθήματα was limiting rather than based on popular perceptions of them.

From the above discussion of why calculation appears in Aristophanic comedy, we also get an impression that mathematics is to some extent morally ambiguous; that is, the audience seems to have been expected to view mathematics negatively in some instances, but positively in others. This is a corollary of the ability to use mathematics as a weapon both for and against those in power, as the audience would feel the effects of both of those uses (when for those in power, mostly negative; when those against those in power, mostly positive). The Aristophanic picture of calculation acknowledges both its persuasive powers and its power to fight its own persuasive power: Dionysus's counting Aeschylus's lines demonstrates the persuasive power, while Bdelykleon's calculations from the public records demonstrate the ability to fight back. Either Aristophanes is encouraging the audience to harness this pugnacious side of mathematics, or the audience is already aware of this side of mathematics, and the scene in *Wasps* between Bdelykleon and his father is an illustration of how they employ it. In any case, persuasion seems to be a main role that calculation specifically takes in Aristophanic comedy.

As noted earlier, the type of calculation ties into its utility and its persuasive ability: calculation rooted etymologically in ἀριθμοί is less useful, and therefore less persuasive, than calculation rooted etymologically in λογισμοί. We could try to explain this distinction with a slow/fast binary, but this would not fully explain the slowness of waiting to count each of Aeschylus's repeated lines although the action is λογίζομαι. While the speed of the calculation plays into its utility and persuasiveness, there must be another element that affects its efficacy. In considering the examples of both the soldiers counting up (ἠρίθμησεν) the enemy in *Knights* and counting (ἀριθμοῦσιν) the voting shells in *Wasps*,²⁸⁶ this sort of calculation is sorting out an already visible mass to make sense of it. On the other hand, when Dionysus counts (λογοῦμαι)

²⁸⁴ Aristophanes, *Clouds*, 636-647.

²⁸⁵ *Ibid.*, 681-692.

²⁸⁶ Aristophanes, *Wasps*, 332-333.

the repeated lines,²⁸⁷ he cannot see the lines as they come: he must visualize them with a counter each time the line is said. Similarly, when Strepsiades in *Clouds* reckons the interest on his debts, he must first remember each debt before jotting it down on his tablet.²⁸⁸ The visualization of the lines and the interest, then, appears as a result of the λογίζομαι, whereas the enemies and shells to be counted (ἀριθμέω) are already visible, but are difficult to differentiate as a mass. In creating a visualization from scratch as opposed to merely sorting an existing group of objects, λογίζομαι as an action brings abstract or mental objects into physicality. Again, this is still not a complete picture, as it leaves the instance of falsifying the records in *Wealth* a bit puzzling (are minas recorded in writing not physical enough?), but it helps to explain why a simple binary of slow/fast does not fully capture the complexity at play.

One mathematical topic, however, is certainly a crock of quackery: astronomy. If we consider Meton an astronomer in *Birds*, from the discussion earlier it is clear that Meton is a quack who swindles the public with his gadgets. Not only is the public being swindled by astronomy, but the gods are as well: in *Peace*, Hermes complains about how the calendar changes so often,²⁸⁹ and the cloud chorus similarly rebukes the Athenians for messing with the calendar.²⁹⁰ Seeing as the Dionysia, where both of these plays debuted, was also a religious festival, the complaints about missing festivals have additional significance, as audience members could have been having the same problems that the gods in the comedies were. *Clouds* further derides astronomy by having the learners' butts learn to do astronomy²⁹¹ and Sokrates agape while gazing at the moon,²⁹² and *Birds* claims that humans could learn everything about the heavens from birds.²⁹³ These are strongly negative depictions of astronomers and what they do, and clearly the audience had a personal interest in stopping them from causing more calendrical chaos, so it seems safe to assume that audience members were not fans of astronomy. Considering the astronomers' motivation for fiddling with the calendar was partly to keep the seasons and festivals aligned, it is ironic that Aristophanic comedy's view of them is the exact opposite, but this likely indicates that what astronomers did (or said they did) was not well understood by the general public.

²⁸⁷ Aristophanes, *Frogs* 1263.

²⁸⁸ Aristophanes, *Clouds* 18-20.

²⁸⁹ Aristophanes, *Peace* 414-415.

²⁹⁰ Aristophanes, *Clouds* 607-626.

²⁹¹ *Ibid.*, 193-194.

²⁹² *Ibid.*, 170-174.

²⁹³ Aristophanes, *Birds* 690.

Since the only named person in Aristophanic comedy who may have left behind mathematical and/or astronomical works is Meton, and, if Meton did write works, none of them survive today, it is hard to know whether Aristophanes actually knew Meton's work when he decided to parody Meton in *Birds*. From the earlier discussion of this scene in *Birds*, however, it is clear that Meton is not depicted solely as an astronomer and in fact wears many (metaphorical) hats in the scene. Nothing about his dialogue is particularly astronomical aside from the fact that a star is mentioned, so it would seem that Meton's astronomical works were not brought on stage with him. This of course does not mean that the audience was necessarily unfamiliar with Meton's work; even if they were unfamiliar with his work, the fact that Aristophanes retained the name Meton for the scene while leaving the other swindlers before and after his appearance nameless means that his name was at least recognizable to the audience. Furthermore, the fact that this name was retained for a Dionysia performance in front of non-citizens means that his name recognition may have stretched beyond Athens. Thus it would be hard to argue that no one in the audience had any awareness of Meton's existence and work in Athens, but it is also possible that little of the real Meton actually made it onto the stage.

To ensure that the scope of this study is wider than just one author, we also considered the corpus of Old Comic fragments. In addition to the μαθήματα found in Aristophanes's works, music appears as something that can be learned with the verb μανθάνω in a play of Kratinos and Eupolis's *Aiges*. However, considering that Sokrates in *Clouds* tried to teach meter and it seems that the teacher character in *Aiges* was mostly unsuccessful at teaching music, there could have been negative connotations with learning music. Music's appearance as something taught in comedy brings to mind one of the most famous musical mathematicians of classical Greece, Archytas of Tarentum. Archytas is reported to have explicitly called music a μάθημα,²⁹⁴ and he applied theories of ratios to music, combining calculation and music.²⁹⁵ We cannot confirm that Archytas was the target of these jokes, and considering his geographical and chronological remove from most Athenian Old Comedy he may not have been in the forefront of the late 5th century BCE Athenian mind. But music as a scorned μάθημα has the potential to have influenced later opinions on musicians. From Eupolis's *Aiges*, at least, it would seem that music was not a necessary pursuit for the average Athenian.

²⁹⁴ Porphyry, *Commentary on Ptolemy's Harmonics* 55.32-57.27.

²⁹⁵ Boethius, *Fundamentals of Music* 3.11.

While the performative aspects of λογίζομαι were present in Aristophanes, they became even more apparent in the fragments. The λογισταί of the chorus,²⁹⁶ the women drinking ἀνεκλογίστως,²⁹⁷ and the character who will reckon (λογοῦμαι) the account untaxed²⁹⁸ all seem to embody performed calculations in the sense that the performance of these calculations is just as important as the result of the calculation. Seeing as most of the verb forms of λογίζομαι found in this study were first person, while ἀριθμέω had only one instance of a finite verb in a person other than third, λογίζομαι is certainly the more personal and interpersonal mathematical action of the two. It is perhaps for this reason that λογίζομαι has more positive connotations in Old Comedy than ἀριθμέω, as well as more total attestations, reflecting how interpersonal relations feature prominently in many comedies (e.g. Lysistrata gathering together the women of Greece, Philokleon and Bdelykleon in *Wasps*, and the potentially shady transaction being offered in Philonides 4).

Measurement was shown to be favored when imprecise in Aristophanes, but Strattis 14 showed how one does not need to travel far outside Athens to realize that systems and units of measurement, whatever the precision, change rapidly and sometimes drastically. From what we have seen, it seems clear that common Athenian measures were well-known amongst the Athenian audience, but knowledge of measures even immediately outside Attica is to some degree specialized. The same line of thinking applies to coinage, as the mention of Byzantium's iron νομίσματα in Platon 103 and the absurd currency of Pherekrates's *Krapataloi* contrast with the everyday mentions of obols, drachmas, and minas used commonly in Athens. Even the idea of the underworld not having the same currency as where one lived while alive, especially when the custom was to provide the dead with money for ferry fare, seems not so farfetched considering the variation of coins that needed to be moderated in the agora by law.²⁹⁹ In Old Comedy, then, knowledge of Athenian measures and coins was commonplace, and fluency in them was almost expected.

One point of contrast between the fragments and Aristophanes is the picture of astronomy. Above it was argued that Aristophanes depicted astronomy as definite quackery, but the three fragments which mention specific celestial phenomena (Kratinos 144, Eupolis 158, and

²⁹⁶ Eupolis 239.

²⁹⁷ Pherekrates 152.

²⁹⁸ Philonides 4.

²⁹⁹ Steven Johnstone, *A History of Trust in Ancient Greece* (Chicago: University of Chicago Press, 2011), 30-31

Theopompos 48) demonstrate that the audience may have had some associations with celestial observation that had real utility. While the astronomy of Sokrates's thought-shop and Meton's description of the sky as a stove cover may have been portrayed as buffoonery, the audience must have at least recognized the importance of the stars for navigation at sea, seasonal changes, and religious festivals. The difference in association could lie in the aspect of prediction: Sokrates and his learners and Meton may have been trying to *predict the motion* of celestial bodies,³⁰⁰ whereas the celestial events mentioned in the three fragments were observations that recommended (or even dictated) action. Sailors at sea were generally not interested in predicting the motion of the stars, but they were interested in finding their way either to their destination or home, which the stars could help them do. Just why predicting the stars' motions seemed so futile in Old Comedy is not particularly clear from what remains, but since each instance of celestial prediction is in a context of other fraudster-like activity (e.g. Sokrates stealing cloaks and Meton "land-measuring the air"), it is possible that whatever utility people had associated with astronomical prediction was suspended because of the other activities accompanying it. This is an interesting precursor to the flourishing of predictive astronomy in the Hellenistic period not long after the end of Old Comedy.

Lastly, the jokes in Old Comedy related to mathematics often seem to be most specific when the joke related to something very visible or a recent event in Athens. Meton in *Birds* appeared on stage with large instruments and uncommon costuming, while the Phyrnikhos fragment points to visibility of Meton's structures; Strepsiades in *Clouds* jokes about the size of the first creditor's belly using the measure *chous*; Bdelykleon uses the public inscriptions to tally up the tribute flowing into Athens and then the amount of it spent; Protagoras is brought up in Eupolis's *Kolakes* shortly after his visit to Athens; Eupolis wrote a joke about a specific harbor tax (the ἐλλίμενον) during a time when harbor taxes were being levied with increasing frequency; and Theopompos made fun of a work of Plato the philosopher potentially soon after its publication. In this respect, these jokes are similar to the many political and slanderous jokes Old Comedy is known for, such as the orator Thukydides's getting cursed in a law court,³⁰¹ the lampooning of Alkibiades for his speech impediment,³⁰² and Agathon's effeminate dress.³⁰³ Thus

³⁰⁰ This is not specifically stated in the plays in which they appear, but it is clear from later sources that the real Meton was in fact involved in this activity in order to "develop" the 19-year Metonic calendar cycle.

³⁰¹ Aristophanes, *Wasps* 946-948.

³⁰² *Ibid.*, 44-51.

math jokes fit in to the mold of Old Comic jokes, but lampooned mathematical people exclusively for their quackery and deception rather than political impotence or personal effeminacy.

In conclusion, it would seem that Old Comedians in general slandered mathematics when used as a tool of deception; at the same time there was an acknowledgement that mathematics could turn that deception on its head, much like an orator spars with a fellow orator with their own tools. Additionally, these comedians held an expectation of fluency in measurement and coin manipulation at Athens to some extent among the audience, but beyond Athens knowledge in these areas became specialist. But when it came to people associated with mathematics (namely Meton, Protagoras, and Plato), from what remains it would seem that the most the audience was expected to recognize was the name. What followed in characterization of the individual was mostly just to get a few laughs. Considering the latest instance of such a lampoon chronologically is also the most accurate, it would be interesting to see what people are targeted in later comedy to see if the slandered individuals became truer to their real-life counterparts. Considering how these math jokes seem stylistically similar to political jokes in Old Comedy, an examination of Middle, New, and perhaps Roman Comedy would allow us to see how the style of jokes related to mathematics changed over time, and if this change lined up with the changes we know happen between Old and New Comedy.

³⁰³ Aristophanes, *Thesmophoriazousai* 130-145.

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