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Literacy in Greek and Chinese Science

Some Comparative Issues

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Work done in the wake of the pioneering studies of Goody and Watt, Havelock, and others has put on the agenda a series of evidently crucial, if highly obscure, questions. If we can all agree that the existence of written records and other types of texts makes a difference, the issue is: what difference? The key questions include: who is in control; who makes the texts; who has access to them; who uses them; and for what purposes? How are those who do the writing recruited and trained? How and by whom is the ability to read them acquired? Who is responsible for the transmission and dissemination of texts or for deciding which texts are for more general, which for only restricted, circulation? What, indeed, did “circulation” consist of, and what, more generally, were the occasions on which the texts were used or their contents performed? We shall certainly not be in a position to appreciate the differences literacy makes in a given society at a given period until we have some idea about the answers to questions like those – not that that list is meant to be exhaustive. To get a sense of those differences, we need, ideally, to take a range of different societies and periods into account: we need, in fact, a comparative approach.

Let me explain my agenda. What were the different effects, on ancient Chinese and Greek science, of the modes of literacy for which we have evidence? I use the term *science* as a conventional placeholder for what passed as the study of the heavens and that of the human body,

and I shall include also the study of health and disease – medicine, in other words – and, indeed, also mathematics.¹ In this chapter, I want to explore one aspect of those differences, namely, what they owed to literacy and, more generally, to what I call the contexts of communicative exchange.

I shall divide my discussion into two parts. The second will tackle the specific question of what the very different styles of mathematics cultivated in China and in Greece owed to the different technologies of communication that were available and that were used. But to get to grips with that I need first, in the more extensive first part of the chapter, to set the scene with a general discussion of those technologies. Let me emphasize, however, that I do not aim at a comprehensive coverage of the issues in the second, specifically mathematical, part of my analysis, let alone in the first scene-setting section. Moreover, even my more limited conclusions are subject to an important general reservation. Neither for China nor for Greece can we be confident that our extant sources provide an entirely reliable database on which to propose valid generalizations. Those sources, in each case, are both biased and incomplete. I shall underline particular concerns over particular points in due course. But the problem is a general one and needs to be borne in mind throughout.

TECHNOLOGIES OF COMMUNICATION IN CHINA AND GREECE

Let me begin with China. By the time of the Eastern Han dynasty (ca. 23–220 C.E.), certain classic texts had acquired canonical status and their transmission and use are comparatively well documented. The canons (*jing*) in question included not just the so-called Confucian classics² but also medical and mathematical texts. The medical classic *Huangdi neijing* (*Inner Canon of the Yellow Emperor*) exists in three different recensions (*lingshu*, *suwen*, *taisu*), thought to have been compiled around

¹ On the differences between the “science” produced in China and in Greece, see Lloyd and Sivin (forthcoming), and on the influence of technologies of communication on early Chinese thought, compare Lewis 1999.

² The five generally recognized Confucian classics were the *Yijing* (*Book of Changes*), *Liji* (*Rites*, or *Records of Ceremony*), *Shijing* (*Odes*, or *Songs*), *Shujing* (*Documents*), and *Chunqiu* (*Spring and Autumn Annals*). These became the standard education for intending officials by edict of the emperor in 136 B.C.E.

the middle of the first century B.C.E. The two chief early mathematical classics, the *Zhoubi suanjing* (*Arithmetic Classic of the Zhou Gnomon*) and the *Jiuzhang suanshu* (*Nine Chapters of the Mathematical Art*) – which I shall be concentrating on below – date from a century either side of the Common Era.

By Eastern Han times, we hear of fictive “lineages” (*jia*) whose primary responsibility was the preservation and transmission of the canonical texts. The classification of philosophical and other groups was sometimes achieved by reference to these lineages – the term *jia* is often translated as “schools.” Those in turn served as the basis for the cataloguing of the books in the imperial and other libraries.³ We hear, too, of schools in the sense of teaching establishments where the study of the canons was carried on. Nor should we think of those schools as serving just the purely disinterested function of promulgating learning. Entry to the imperial civil service depended, generally, on knowledge of the primary canons. The schools themselves came to be judged by how successful their pupils were in gaining the top jobs in the imperial bureaucracy. The study of the key texts was crucial not just for gaining a reputation for learning, but for a career.

However, if those are among the clearly defined features of the organization of learning in the Eastern Han dynasty, how far do they apply also to earlier periods? Recent scholarship has served to highlight the dangers of reading too much of the Eastern Han picture backward, even to the earlier, Western Han dynasty, or to the Qin, let alone to the preunification situation of the Warring States period. One of the first classifications of six prominent *jia* comes in the final chapter of the *Shiji*, which contains Sima Tan’s ideas, recorded by his son Sima Qian. But that chapter does not mention texts as such in any prominent role in that context. Those six *jia* are differentiated in the first instance by the way they set about giving advice on government.⁴ They represent Sima Tan’s ideas on *that* subject, not his thoughts on the structure of philosophical lineages. Although on the basis of scattered references in the *Shiji* and

³ The earliest extant comprehensive bibliographical survey is in Chapter 30 of the *Hanshu* by Ban Gu (ca. 90 C.E.), drawing on the work, now lost, of the imperial librarians Liu Xiang (died 8 B.C.E.) and Liu Xin (died 23 C.E.). Cf. Lewis 1999: Chapter 7.

⁴ *Shiji* 130, 3288–9. See Petersen 1995; Smith (forthcoming); Csikszentmihalyi and Nylan (forthcoming).

elsewhere it used to be held that in the fourth century B.C.E. there was already an important prototype of an imperial Academy founded by King Xuan at the Ji gate of his capital city Qi, that idea has now been exploded as another case of reading back later institutions into an earlier period.⁵ Like many kings and powerful ministers of the Warring States period, King Xuan aimed to collect around him as many brilliant “guests” as he could. They included several prominent thinkers, such as Zou Yan, but there is nothing in the earlier, more reliable evidence that suggests that these “guests” formed a school or had any kind of teaching function.

We have, then, to be on our guard. Some of the conventional accounts, accepted until quite recently, of the early Chinese philosophical “schools” need to be reexamined more critically. The primary sources on which they are based cannot be accepted at face value as historical accounts, but come from authors with their own definite, often polemical, agenda. This applies not just to Sima Tan’s account, preserved in the *Shiji*, but also to the groupings found in *Zhuangzi* 33.⁶ There too, as in *Shiji* 130, other philosophers are criticized for having appreciated only part of the truth, or the Way. That chapter is thought to date from some time in the second century B.C.E., but even earlier, Xunzi, at the end of the third century, attacks twelve thinkers not so much on purely intellectual grounds as for the disastrous advice they offered on government and social relations.⁷ Among those criticized is no less a figure than Mencius (Mengzi) – one of the most famous and respected of the interpreters of Confucius’ thought in the fourth century. Yet, according to the conventional view, Xunzi himself was a “Confucian.”

Such a term as *ru* (“literati”), used of those who are often labeled Confucian, indicates sometimes no particular allegiance to the teachings of Confucius (Kong Fuzi) himself, but rather a reputation as a figure of learning. Where the conventional view sees the legendary Lao Dan as the founder of “Daoism,” we must be clear that following the Way was an ideal that was far from the exclusive characteristic of those who admired such canonical texts as the *Daodejing*. On the contrary, it was

⁵ Sivin 1995b: Chapter 4, 19–28.

⁶ On *Zhuangzi* 33, see Graham 1989: 376. The chapter in question does not belong to the earliest stratum of *Zhuangzi* (the so-called Inner Chapters), but dates perhaps from the second century B.C.E.; see Graham 1981.

⁷ *Xunzi* 6, on which see Knoblock 1988–94: 1.212–29.

a goal shared by philosophers of widely differing views, even though they disagreed on precisely what following it entailed. The term *Mohists* is slightly more determinate, referring to the followers of Mo Di, often thought of as the chief fifth-century rival to Confucius himself. Yet both *Zhuangzi* 33 and *Hanfeizi* 50 report factionalism within their ranks and disagreements on the interpretation of the Mohist canon.

If we should be cautious about accepting the classificatory framework within which early Chinese philosophy is generally discussed, what, positively, can be said about the way in which texts were used, and about the conduct of philosophical inquiry and the ambitions of philosophers more generally? Due allowance must be made for the variety of texts that have come down to us or that are reported or described in our sources. Beyond the medical and mathematical classics that I shall discuss below, the so-called Confucian classics include, for instance, the *Book of Odes* and the *Spring and Autumn Annals*, the former a collection of poetry, the latter a record (attributed to Confucius himself) of events in the state of Lu from 722 to 491 B.C.E.

However, to tackle the questions raised in the last paragraph, we may take the evidence that the *Lunyu* (*Analects*) – also ascribed to Confucius – provides. This, like so many of the early texts that are extant, is nowadays thought of as a compilation, put together over an extended period, maybe from early in the fifth century to the middle of the third B.C.E.⁸ This text represents Confucius in conversation with his pupils – Zilu, Zigong, Zixia, and so on – and other interlocutors. We have, then, what purport to be dialogues, or at least exchanges, and one lesson we are to learn is that Confucius tailors his replies to the situation and to his interlocutor's progress in understanding.

As written representations of what purport to be live conversations, the analogies with Plato are obvious. Yet two points of dissimilarity stand out immediately. First, the *Lunyu* itself became a text that the pupil had to master, indeed to memorize, as part of his induction into the group. It is clear from other sources that it was only after the text had been committed to memory that the pupil began to turn to its interpretation.⁹ Learning the text by heart was a kind of rite of passage,

⁸ Brooks and Brooks 1998 date the various strata that they postulate between 479 and 249 B.C.E.

⁹ See, for example, Sivin 1995a.

testimony to the seriousness and dedication of the student. The pupil's admission to the lineage depended as much on his character and moral probity as on any intellectual attainments he might display. The duty of members of a lineage, *jia*, in Eastern Han times at least, was to hand on and preserve the canonical text, the *jing*. Second, Confucius was not just interested in teaching disciples. His ambition was to find a ruler who would accept his advice about government. His primary preoccupation, throughout, was with human behavior and social relations. But this was not (as we say) an academic interest. He desperately wanted to see his ideas implemented, desperately indeed, since in the event he never did find a ruler who would implement them.

At this point, one might think of Plato's equally desperate attempts to influence Dionysius II, tyrant of Syracuse. Certainly, those attempts were also driven by Plato's sense that he needed at least to *try* to find someone to carry out some of his political program. Yet after his disastrous third visit to Sicily, Plato's sphere of operations was Athens. The Academy he founded was, indeed, to be a training ground for statesmen. But the personal goal of its members was leading the philosophical life – an end in itself.

More important, Confucius' ambition to influence rulers was shared by many, maybe even most, early Chinese philosophers. The list of those who sought to act, and indeed acted, as advisers to rulers includes Mencius, the Mohists, Hui Shi, Gongsun Long, and Han Fei. The *Daodejing* has a lot to say about the cultivation of the self, but the policy of *wu wei*, "no ado," is one that rulers are advised to follow. In parts of the *Zhuangzi* compilation, too, the issue of good government comes to the fore even while other sections promulgate an ideal of other-worldly disengagement. At the end of the Warring States period and the start of the imperial period inaugurated by the Qin and carried on by the Han, we have a series of works that provide comprehensive summaries of knowledge and cover a diverse array of subjects, including the calendar, music and ritual, agriculture, and not least government itself: the *Lüshi chunqiu*, put together around 239 B.C.E. by Lü Buwei (prime minister to the man who later unified the empire); the *Huainanzi*, compiled under the direction of Liu An, king of Huainan, before 139 B.C.E.; and the *Chunqiu fanlu*, the work, in part, of the prominent statesman Dong Zhongshu, around 134 B.C.E. But in each case these were compiled by or under the direction of statesmen; their principal aim was to set out the

knowledge the ruler will need for good government, not just a matter of what we might call political theory, to be sure, but everything required for a correct understanding of the world as a whole.

The target at which much Chinese philosophical writing is aimed is the ruler, to whom advice was often offered in the form of the “memorial to the throne.” Such “memorials” had to be written to be presented. No one would dream of just speechifying in front of the emperor if they had an important proposal to put to him, nor would they have been allowed to do so. Dong Zhongshu is the author of some remarkable examples,¹⁰ and before him, Li Si, prime minister to the first Qin emperor, produced in 213 B.C.E. a famous “memorial” advocating the burning of philosophical texts in private hands. The latter example shows that collections of such texts were common enough to be seen as a threat by authorities who saw their contents as subversive.¹¹ But the ruler was the target, not just because he was in a position to implement policy; he was also the prime source of patronage. Even before the civil service expanded as it did, exponentially, under the Han dynasty, the courts of rulers were an important source of support for intellectuals of different types.

The teaching function is thus often subordinated to the task of persuading the ruler or his ministers. Of course, Chinese intellectuals also sought to impress other intellectuals, and they criticized other groups of individuals often enough (though more often the dead than their still living contemporaries). Yet the main type of occasion on which debates or discussions were held was in the presence of the ruler, and more often than not on matters of state policy (one example is the discussion represented in the *Yantielun*, the discourses on salt and iron).¹² Dialogues between master and pupil appear, as I remarked, in the *Lunyu*, and the *Zhuangzi* produces some striking exchanges where Confucius is worsted, including one, for instance, at the hands of the notorious robber Zhi.¹³ But in every discipline pupils were expected to adopt a deferential, even reverential, tone toward their masters. They were certainly not expected to challenge or contradict them.

¹⁰ See, for example, *Hanshu* 56, discussed by Queen 1996: 249–54.

¹¹ Two slightly different versions of Li Si’s “memorial” are given in the *Shiji* 6, 254–6 and 87, 2546.

¹² See Nylan 1994 for an analysis of the evidence on the courtly conferences and debates down to the second century C.E.

¹³ See, for example, *Zhuangzi* 29.

This leads to concrete evidence for the role of texts in the transmission of medical learning in particular. Li Si's "memorial" excluded technical treatises from his ban, which helps to confirm their existence and importance. Works on medicine and agriculture were specifically excepted.¹⁴ We find, indeed, many examples of medical texts alongside philosophical and literary ones, in the tombs that have been excavated from the late Warring States and early Han periods. We also have some evidence as to their role. In the biography of the doctor Chunyu Yi contained in *Shiji* 105, Chunyu Yi describes how he came to learn medicine. He was apprenticed first to a doctor called Gongsun Guang, who teaches him a number of "formulas" (these appear to include both written texts and oral teaching). Chunyu Yi swears, in return, not to divulge these inappropriately to anyone else ("I would die sooner than transmit them wrongly to anyone"). But when Gongsun Guang has taught him all he knows, he recommends another doctor, Yangqing: "His formulas are exceptional, not the sort that the uninitiated know about." Gongsun Guang provides him with a letter of introduction, and we are given an account of Chunyu Yi's first encounter with his new teacher. When it became clear that he was accepted for instruction, he not only expressed his delight but "left his mat and made repeated obeisances."¹⁵

The evidence from Chapter 48 in the *lingshu* recension of the *Huangdi neijing* enables us to go a step further. This chapter gives a fictional account of the Thunder Duke receiving a text from the Yellow Emperor himself. This is preceded by the Thunder Duke undergoing purification for three days and then sealing his oath with a ritual in which he cuts his arm and smears the blood. Thereupon, the Yellow Emperor "grasped his hand with his left hand and with his right conferred the book on him, saying 'Take care. Take care. I will now explain it to you.'"¹⁶

We shall be returning to mathematics at the end, but for now let me summarize the chief points that have emerged so far from this rapid survey. First, we must be wary of the diachronic dimension to the problems. In the Eastern Han dynasty, there were academies training people in the classics partly as a means of gaining access to posts in the imperial civil service. By then, the term *jia* was used of the fictive lineages that

¹⁴ Exceptions were also made for technical treatises on divination, as well as of the official histories of the state of Qin itself.

¹⁵ This text is analyzed in Sivin 1995a: 178–84; also cf. Hsu forthcoming.

¹⁶ See Sivin 1995a: 184–8.

had responsibility for the preservation and transmission of the canons (*jing*). There are continuities, but also discontinuities, with earlier practices. Pupil–teacher entourages go back to the fifth century, but they were less formal than the Han academies. More continuity can be seen in the manner in which texts were transmitted. Even though the use of the term *jia* to describe the fictive lineages involved is mainly an Eastern Han development, the medical evidence especially suggests that much earlier the transmission of the text *could* be a solemn affair, with the pupil granted access subject to a ritual initiation.

Let me turn now, even more rapidly, to the Greek evidence, to bring out the chief general points of similarity and dissimilarity with the Chinese data. In this case, too, there are important discontinuities and transitions that have to be borne in mind in evaluating the relative roles of the written and oral modes of communication at different periods and for different genres. I shall concentrate, at this stage, on philosophy and medicine.

While written texts are attested from Anaximander onward, it is well-known that when they were consulted, they were more often read out and discussed than studied privately and in silence.¹⁷ This is what Plato describes as happening in the case of the book Zeno is said to have brought to Athens (*Parmenides* 127cd). Although Plato does not spell out what the book contained, it undoubtedly included technical philosophical argumentation. What was the nature of the discussion that followed such a reading? Plato's dialogues purport to represent some such, though they are, of course, fictional accounts of considerable artistry. When he stresses that Socrates will follow wherever the argument leads, he wants to underscore the contrast with the persuasive arts of sophists whose sole concern (Plato would have us believe) is to please the crowd. Yet even if we should discount the rhetoric of Plato's appeal to the truth as arbiter, it is still obvious that the contexts of these exchanges are rather different from those normally encountered in China, even those of Confucius' exchanges with his pupils, let alone that characteristic Chinese situation, the presentation to the throne. The key point of difference is the assumed equality of the interlocutors in Plato's dialogues.

¹⁷ See Thomas, this volume, on public reading of written texts; see S. Usener 1994 on reading in the fourth century.

Some of our early medical evidence, from the Hippocratic Corpus, serves to throw more light on what were apparently common contexts of oral communicative exchange. *On Diseases I* offers advice on how the doctor should deal with the question-and-answer sessions he can expect to have not just with patients, their relatives, and their friends, but also with other doctors, who are present at the case and keen to debate the diagnosis and treatment.¹⁸ We recall from Plato that Hippias, Gorgias, and others prided themselves on their ability in analogous sessions, even though they were no match for Socrates (Plato implies) in that department.¹⁹ We hear, indeed, of several sophists who publicized themselves at the Panhellenic games by giving lectures and offering to answer questions afterward.²⁰

Some of the Hippocratic works represent, or at least originated in, such lectures (*epideixeis*).²¹ One such is the treatise *On the Nature of Man*, which opens by addressing those who are accustomed to *hearing* a different approach to medicine. That work describes lectures given by rival speakers – on the subject of the constitution of the human being, no less – where the aim was evidently victory as decided by the crowd of bystanders.²² That was just the kind of situation that Plato contrasted with true philosophical debate (though there is no need to agree with his condemnation). Such occasions were, to be sure, partly entertainment, but they also served to raise the public's interest in a wide range of questions.

The model that such debates bring to mind is, of course, that of the law courts and the political assemblies, where Greek citizens of the classical period acquired considerable experience in evaluating arguments for and against various propositions, on guilt and innocence, and on

¹⁸ *On Diseases I* 1, discussed in Lloyd 1979: 91–2. The advice on question-and-answer sessions contained in this treatise would have no point if it did not correspond to a possible real-life situation. Other treatises, discussed in Lloyd 1979: 90, confirm that doctors had good reason to be concerned lest a consultation be turned into a public lecture.

¹⁹ For Hippias, see Plato, *Lesser Hippias* 363c–d; for Gorgias, *Meno* 70c, *Gorgias* 449b–c; for Protagoras, *Protagoras* 318b, 329b, 336b–d.

²⁰ See Plato, *Lesser Hippias* 368b–e; Aristotle, *Rhetoric* 1414b29–34, discussed in Lloyd 1987: 91–2.

²¹ See Thomas, this volume.

²² *On the Nature of Man* 1, discussed in Lloyd 1979: 92–4, quoted and discussed by Dean-Jones, this volume: 115–16.

matters of state, including the constitution itself. The decision rested with them in their role as jurors or members of the assembly. It is not at all surprising that no Chinese philosophical or medical debate follows that pattern, since there is simply no Chinese parallel for the Greek experience of a citizen acting as both judge and juror in lawsuits, or of citizens gathering to make decisions in an assembly that was plenipotentary.²³ I shall have more to say about the influence of this model elsewhere on Greek intellectual life when I come to mathematics.

Of course, unless qualifications and exceptions are noted, my Greek picture will seem quite unbalanced. The Hippocratic works I have mentioned, like Plato's dialogues, are themselves all written productions, artful ones at that, and the fact of their being committed to writing serves to make them available, as Goody argued, for a different type of ruminative critical scrutiny than any that can be given to an oral performance – the original lectures themselves.²⁴ Moreover, some works in the Hippocratic Corpus are very different from the type of demonstration lecture (*epideixis*) I have spoken of. Some treatises record detailed case histories, deal with problems to do with surgical procedures, or set out lists of drug recipes.²⁵ While many insist on open exchanges between doctor and patient – and on the doctor being intelligible to lay people – some suggest that medicine is not to be taught to just anyone. *Oath 1* limits that instruction to family and to those who have sworn the oath. *Law 5* puts it that “holy things are revealed only to holy people. Such things must not be made known to the profane until they are initiated into the mysteries of knowledge.” The Thunder Duke would have approved.

Going further afield, we know that by the end of the fifth century a fair body of technical literature had already been produced in such fields as agriculture, architecture, astronomy, and harmonics. Private

²³ The Chinese political ideal, accepted in all our extant classical Chinese sources, is that of the benevolent rule of a wise monarch. The differences between Greek rhetoric, envisaging, primarily, Greek law courts or political debates in the councils or assemblies, and Chinese rhetoric, directed principally at persuading the ruler or his ministers, are examined in Lloyd 1996: Chapter 4.

²⁴ Goody 1977: Chapter 3. See Yunis, this volume, on differences in attending an oral performance and reading a written text.

²⁵ See Lonie 1983 on the interplay between oral and literate communication techniques in the Hippocratic Corpus.

collections of this material were beginning to be made, though Euthydemus' library, reported in Xenophon, was clearly exceptional.²⁶ If we go further afield in time and allow for the diachronic dimension, one increasingly important new genre is the commentary.²⁷ Homeric scholarship and exegesis were well established in the fifth century, and by the end of the fourth Hippocratic scholarship flourished in Alexandria. Apollonius of Citium writes a commentary on the work *On Joints* in the first century B.C.E., and by Galen's day, three centuries later, Hippocratic commentaries were not just a vehicle for philological analysis but a battleground where rival claims to appropriate the authority of the model physician were debated.

Even when these and many other reservations are added, there are still important differences between some Greek and some Chinese communicative situations. Both societies used oral and written modes, to be sure. But there is no Greco-Roman parallel to the Chinese use of their canonical texts as the basis for examinations to enter the imperial civil service. Again, Chinese debates are less often face-to-face and never (as far as I know) judged by a lay audience. Greek intellectuals, philosophers, and doctors did not generally think of the ruler as the person to persuade, but sought to impress their peer group or even the general public. With fewer opportunities for patronage or state support, the Greeks relied more heavily on teaching to make a living, and there your reputation and livelihood depended on your performance in lectures and face-to-face debates.

STYLES OF MATHEMATICS IN CHINA AND GREECE

Now that the scene has been set, I want to turn more briefly to the particular evidence for the development of mathematics, a useful test case since it is an area where we might expect the importance of the written mode to be particularly pronounced. Although we have only paltry fragments of Greek mathematics before Euclid, the corpus of work

²⁶ Xenophon, *Memorabilia* 4.2.8. See Jacob 1998 for an excellent comparative study of the rise of Greek and Chinese book collecting and libraries.

²⁷ The rise of the commentary as a genre in the Greco-Roman world and in China is now the subject of a considerable secondary literature. On the Greco-Roman side, see Cambiano 2001; on the Chinese side, see Lewis 1999: Chapter 6; Sivin in Lloyd and Sivin (forthcoming): Chapter 2.

ascribed to him offers an excellent example of the types of technical treatises that came to be produced in increasing numbers in the Hellenistic period. On the Chinese side, there are two important classics that I mentioned before, the *Zhoubi suanjing* and the *Jiuzhang suanshu*, which provide the basis for a close comparison and contrast between these two traditions. The questions on which we can thereby hope to shed light are (1) what Greek and Chinese mathematics owed to the written mode and (2) whether the differences between them reflect differences in the technology of writing in question.

The treatises in the Euclidean corpus, not least the *Elements* itself, represent one extreme end of the spectrum from the point of view of *impersonality*. Euclid himself does not just not obtrude: he is invisible, and his life and character are unknown quantities. Nothing, we might say, could be further from rhetoric and rhetorical self-advertisement than mathematics. Precisely. I shall come back to that.

Neither Euclid nor the Chinese mathematical classics are conceivable without writing. On both sides, however, we can detect the direct or indirect influence of oral modes of communicating, and maybe even more important general cultural influences. Where Euclid is concerned, Netz's fine recent analysis identifies an oral background (1) in the use of formulae, (2) in the structure of proofs, and (3) in the references to the immediately present visible object, the lettered diagram (the key element that secures the necessity and generality of the proofs).²⁸ At the same time, the *Elements* is inconceivable apart from the written mode. This emerges clearly as soon as we consider its architectonic structure.²⁹ The whole is a systematic presentation of most of the mathematics known to the Greeks at the time, and the systematic character of the presentation depends on the decisions Euclid (or his predecessors) made as to the logical sequences of theorems and problems – which of these are elementary, which derivative or dependent. Yet while we cannot

²⁸ See Netz 1999: 19, 297. The lettering of the points in the diagram serves as a convenient mnemonic aid. The situation of communication that the mathematical reasoning presupposes can be envisaged as, initially, an oral one, with the discussion of the problems of proof and construction presented by the diagram. But writing evidently becomes necessary when highly complex chains of interconnected arguments are assembled in systematic and comprehensive wholes such as the *Elements* as we have it.

²⁹ See especially Mueller 1981.

reconstruct the processes whereby those decisions were taken, it is sufficiently clear that the whole structure of the discussion, in thirteen books, would not have been possible without written notes.

While neither the *Nine Chapters* nor the *Zhoubi* has that kind of structure (in particular, neither attempts a sequence of deductive proofs from a given, limited axiom set), both are comprehensive discussions of a wide range of problems. While both are written compositions of considerable complexity, the oral mode influences each of them directly. Both take the form of dialogues, even though in the *Nine Chapters* the speakers are not named. There is an anonymous questioner, and an answer is introduced by the expression “the Art (or Method) says.” But in these dialogues, Chinese teacher–pupil relations are very much in evidence. In the *Zhoubi*, the pupil Rong Fang asks the Master, Chenzi, about what his Way can do; for example, has he heard that it can comprehend (or calculate) the height and size of the sun? Chenzi replies that indeed all the things Rong Fang mentioned can be attained by “mathematics,” *suan shu*, the art of numbers. “Your ability . . . is sufficient to understand such matters if you sincerely give reiterated thought to them.” In practice, however, Rong Fang, having gone away to try to solve the problems on his own, has to admit defeat, and it is only after a succession of humiliations that Chenzi concedes to explain his method.³⁰ Even in the *Nine Chapters*, the opening of each section takes the form of questions on particular examples, with their solutions given in the answers. But quite *how* the solutions are arrived at is delayed and, indeed, sometimes emerges only from the accompanying commentaries.

Not just the style, but also the content and aims of the Chinese works reflect Chinese patterns. The overall aim is not (as in Euclid) the axiomatic-deductive proof of the totality of mathematics, but (as the commentator Liu Hui says) to find the guiding principles, the *gangji*, that unify different areas of mathematics.³¹ The parallels between the principles useful in different types of problems are the overriding concern – unity, then, rather than deductive structure. Once he becomes a master of such guiding principles, the pupil can be expected to

³⁰ See Cullen 1996: 176–81 on *Zhoubi suanjing* 23.

³¹ Liu Hui’s commentary is included in Qian Baocong’s edition of the *Jiuzhang suanshu*. He refers to the *gangji* of mathematics in, for example, his commentary to Chapter 1 at 96.4.

practice the Way on his own, and it is not just the pupil in the dialogue, but the reader of the text, who can expect to have to serve a lengthy apprenticeship to master that Way.

If Chinese mathematics reflects Chinese views about the teacher–pupil relationship and the acquisition and internalization of knowledge more generally, Euclid too reflects Greek cultural values in his very different way. Euclid’s chief concern, as I said, was with proof in the axiomatic-deductive mode, proceeding from indemonstrable premises to incontrovertible conclusions. The premises themselves are meant to be self-evident. The definitions, common opinions, and postulates are introduced without comment, and only when we reflect on competing views (alternative definitions or challenges to the status of the parallel postulate as a postulate) do we see the prior decisions that the presentation of the primary indemonstrables involved. But the solutions of problems and the proofs of theorems thereupon proceed in a very different way from the Chinese practices I have described. The proof often consists in, or at least crucially depends on, the construction of the diagram (*graphō* means both “draw” and “prove”).³² But here everything is transparent, as the lettered diagram is built up in a sequence that follows the order of the Greek alphabet. Here, the idea is *not* to get pupils to work it all out on their own, but to take the pupils/readers through a sequence of unchallengeable steps to see that the conclusion *must* follow. The pupils/readers are to be overwhelmed by the conclusiveness of the demonstration: “which was what was to be proved,”³³ as the proofs end. Who can fail to agree? The reasoning is claimed to be universally valid. It does not depend on the assent of individuals, for such assent can only be given by anyone who can understand the argument. Objections that appeal to some particular viewpoint are irrelevant. The impersonal nature of the reasoning thus secures its objectivity.

Yet that style of demonstration itself owes something to the political and legal settings of Greek adversarial culture previously mentioned.³⁴ One stimulus to the development of that mode of deductive proof comes, I suggest, from the negative models that rhetorical debates provided; mere persuasion, the philosophers argued, as practiced in the law courts

³² Netz 1999: Chapter 1.

³³ ὅπερ εἶδει δεῖξαι, quod erat demonstrandum.

³⁴ Lloyd 1996.

and political assemblies, was not enough. To secure the truth, you must have incontrovertibility, to be attained by a combination of self-evident premises and valid deductive argument. Of course, Aristotle was the first to define strict demonstration as depending on those two requirements. But it was chiefly the mathematicians who exemplified it in practice. We might think that that is an obvious, even inevitable, goal for mathematics to set itself. Yet the fact is that neither Chinese nor Indian nor Babylonian nor Egyptian mathematics shared that aim. The Chinese were concerned not with axiomatisation, but with the general unifying principles of mathematics. But those differences between the different mathematical traditions are less surprising once we take into account the influence of those negative models in the Greek case – and the *absence* of such a stimulus in the Chinese one. Axiomatic-deductive demonstration was the ultimate weapon in Greek battles in persuasion.

To sum up on mathematics: in both Greece and China the mathematics practiced (as evidenced in our extant texts) depends, in certain crucial and distinctive ways, on the written mode. The most important aspects of this relate first to the role of writing in the transmission of canonical texts and second to the part that writing necessarily played in the construction of complex interconnected reasoning. However, the distinctiveness of the mathematics produced in either society depended neither on the mere use of the written mode nor on the particular modes of writing employed. Rather, it reflected general cultural and political factors, the different ideals and aims of learning, and the different conceptions of how learning should be transmitted.

CONCLUSION

In both ancient Greece and China, due attention must be paid to the diversity of communication situations and to the varied uses to which written texts of different types were put. We should guard against attempts to generalize from what is true of poetry, or poetic performance, or of the use of official records, all the way to philosophy and mathematics and medicine. Where those last two fields are concerned, there appear to be differences in how texts were used and in the balance between orality and literacy. In China, the role of texts treated as canonical is greater than in classical Greece, though in both societies the importance of canonical texts increases in time if we compare the Han

with the Warring States or the Hellenistic with the classical period. But even Confucius looked back to what he thought of as the learning of the Sage Kings: a figure such as Theseus just does not rate beside the Yellow Emperor or the Duke of Zhou.

The intense Chinese respect for the canonical texts of past wisdom did not preclude disagreement, but the sense of loyalty within the lineage was, in general, far greater than what obtained in Greek philosophical groups such as the Academy or medical groups such as the Herophilean school.³⁵ (Perhaps the Epicureans were an exception.) Brought up in a culture of debate and probably owing more of their instruction to the oral mode, Greek pupils were not above challenging, and even refuting, their teachers in ways that cannot be paralleled in our Chinese evidence whether from the Warring States or from the Han periods.³⁶

In both ancient societies, the literate formed a privileged elite, and in both the importance of written texts for many different purposes grew over time. But the nature of that importance and the trajectory of that growth were not the same. Yet the features that make for the differences, as described here, are not those that relate to the specific technology of the written word. None can be said to derive from, or even to be influenced by, the specific alphabetic or logographic modes of writing used in Greece or China. Rather, they all relate to wider political, social, or cultural values. No doubt, we have much more to learn about the specificities of the uses of literacy both in China and in Greece throughout their varied histories, but it is salutary also to attempt to use each of those two ancient societies as the contrast set for the other.

³⁵ See von Staden 1989 on Herophilus.

³⁶ On the broader issues relating to the divergent cultural ideals of learning that can be found in ancient Greece and China, see Lloyd and Sivin (forthcoming).