Comparison of Chinese and Australian attitudes to CAS in education

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Abstract

Various articles in both academic journals and the popular press over the past decade have attempted to uncover the reasons for Chinese success in school mathematics. As ranked by PISA, Chinese students consistently do better than their Western counterparts. Reasons which have been proposed (in the West) include more time for mathematics in schools, greater knowledge of mathematics (as well as ability) by the teachers, greater involvement by parents in their child's education, and an over-riding ethos that every child can succeed. It is notable that Chinese mathematics (prior to university) puts a high emphasis on technical skills in algebra and geometry (and in some provinces, calculus), and is very focused on success in examinations. The Chinese approach has its critics, but there is no doubt that whereas mathematical standards, as measured by international tests, seem to be slipping in the West, those standards remain very high in China. The Chinese approach however seems to provide little space for experimentation in mathematics, and in particular for the use of technology. Educators in the West are slowly realizing that using computer algebra systems can greatly enhance learning of, and interest in, mathematics, and that the use of such systems seems not to impair technical skills. This article is an initial investigation into the use of CAS in the context of the Chinese education system, and how attitudes differ from those in the West.

1 Introduction

Every few years the Programme for International Student Assessment (PISA) of the OECD tests 15 year old school students across a range of disciplines, including of course mathematics. Table 1 shows the results from China and a handful of predominantly English speaking countries, for the two most recent years of PISA assessment [6, 7].

It is immediately seen that Chinese students consistently outperform students in other countries. The 2012 results unleashed an unedifying storm of comments [1, 10]; some (American) writers insisting that the Shanghai scores were due to only the best students being tested, rather than all students; these accusations were refuted by other American as well as Chinese writers and academics.

Place	**2009**	**2012**
China Shanghai	600	613
Singapore	562	573
China Hong Kong	555	561
China Macao	525	538
Canada	527	518
New Zealand	519	500
Australia	514	504
OECD Average	**494**	**498**
United Kingdom	492	494
USA	487	481
(Lowest)	333	368

Table 1: PISA mathematics results from selected countries and regions

However, a study in Australian schools [11] has found that Chinese international students tend to perform better than their local peers, which would seem to indicate some cultural element.

The following have been proposed for Chinese success in school mathematics [8] :

1. There is more school time given to mathematics.
2. Teachers know more, and are themselves better at, mathematics than their Western counterparts.
3. Parents are heavily invested in their child's education, and put time and effort into ensuring their success: extra tutoring for example.
4. Children are expected to succeed.
5. The Confucian ethos of hard work and persistence does not exist to the same extent in the West.

However, the Chinese themselves are aware that their mathematics instruction methods are not necessarily perfect: that the "traditional deference to authority, breeds a conformity which could be detrimental to creativity" [10] , and also that there is nowhere to go in a success-driven system for students who, for whatever reason, don't succeed.

There has been a considerable sharing of ideas between China and the West in regards to mathematics teaching, with numerous teacher exchanges and an open-mindedness to learn from each approach. Chinese mathematics teaching tends to be highly prescriptive, textbook-based, and measured–every child in a class will be on the same page of the same textbook at the same time. Western educators favour a more flexible approach where students might be streamed into different groups working on different problems, or moving through their texts at different speeds. Chinese educators will have spent much of their university degree learning about mathematics and mathematics education–even in primary schools teachers are discipline specific –generalist Western primary teachers will not have had nearly as much exposure to mathematics in their teaching degrees.

The Chinese approach to learning and teaching means it is very difficult for a teacher to develop a new curriculum or teaching style: what is to be taught, and how it is to be taught, are mandated by Government decisions; it is the job of the teacher to ensure that the Government's regulations are precisely followed. Teachers in the West have far more freedom in how they decide to teach the curriculum.

The introduction of technology in mathematics teaching and learning brings much of the differences between China and the West into sharp relief. Several decades of intense research has shown that the use of such technology as CAS Calculators can re-engage students, and revitalize tired curricula. See, for example, Herron et al. [2] for the results of a recent study. Moreover, students who have learned their mathematics experimentally and experientally through CAS show no lacking in technical skills from students who have learned a more traditional skills-based curriculum. However, old habits die hard, and certainly many educators are doubtful about the use of computational tools as part of a mathematics curriculum.

There has been hardly any research or discussion into mathematics education at a tertiary level, and the differences inside and outside China, although this state of affairs is changing [3]. However, we may take as axiomatic that differences in schools would lead to similar differences in universities and colleges: students and teachers in both places have gone through the same educational background, and would be expected to teach and learn in a similar manner to that at school.

2 The Survey

A survey on the use of CAS in universities was distributed to academics in both Australia and China– the survey was prepared and distributed according to the regulations of the Human Ethics Research Committee at Victoria University; this committee oversaw the survey, and ensured that it satisfied all of the ethics requirements.

The survey consisted of a number of questions, Likert scale, Yes/No, free text, to solicit respondents' knowledge of CAS, uses of CAS, and opinions of CAS.

The survey consisted of several different sections: demographic (age, position, students taught, experience of using CAS), and then branches depending on whether the participants was currently using CAS, had used CAS in the past but not currently, or have never used CAS. The survey ended with some general review questions about attitudes towards CAS in teaching, as the flow chart in figure 1 shows.

This means that not everybody in fact completed the same set of questions; the branching ensured that the questions were geared to the participants knowledge of, and use of, CAS.

The survey was distributed to tertiary mathematics educators in Australia, and in Shanghai, and there were about 40 Australian responses and 60 Chinese responses. There were some immediate differences in the demographics:

- Far more Chinese educators were in the 45–54 age bracket than Australians (25% from China; 10% from Australia)
- Far more Australian educators were in the 55-65 age bracket (32% of Australians; 5% of Chinese)
- Far more Australians had student cohorts primarily of science and engineering (82% of Australians, 21% of Chinese) and also of Education (58% of Australians, 7% of Chinese). However, these figures are misleading, as fewer Chinese educators named different cohorts.

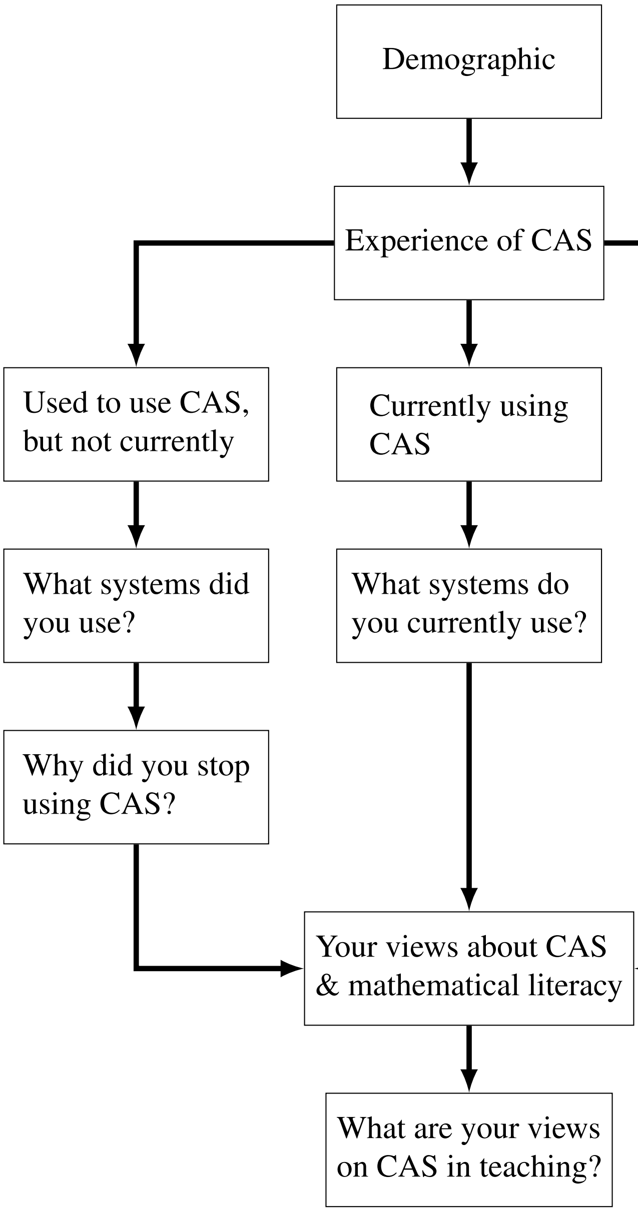


Figure 1: The schematic of the survey

With experience of using CAS in teaching, far more Australian had, or were currently using CAS, than Chinese:

- 79% of Chinese respondents had never used CAS for teaching, as opposed to only 26% of Australians
- 3% of Chinese had once used CAS but not currently, as opposed to 18% of Australians
- 10% of Chinese educators are currently using CAS, and 21% of Australians.

These numbers alone, irrespective of further analysis, indicate what we would expect from the didactic and prescriptive model of Chinese mathematics education. In the current Chinese system, it seems difficult for an individual academic to experiment with new methods of teaching, or to replace a drill-and-practice pedagogy with a more experimental one.

Of the educators currently using CAS, the Chinese educators were evenly spread between using it in the classroom and using it to prepare material (for example, calculus questions which have simple, integral answers), with one lone respondent claiming to use CAS for assessment. In comparison, Australian educators were evenly spread amongst those three uses.

There were several questions asking about exposure to different systems, including commercial (Maple, Mathematica, Matlab), open source (Octave, Sage, Maxima), handheld (TI-nspire CAS, Casio ClassPad, HP Prime calculators), assessment software (Pearson MyMathLab, Wiley Assist, MAA WeBWorK, STACK), dynamic geometry software (GeoGebra, Cabri Geometry, Geometers Sketchpad). Respondents were asked to note whether they had heard of this software, and whether they had ever, or were now, using it. As might be expected, the commercial entities, in particular Mathematica, Maple, Matlab and some of the CAS Calculators, had the greatest exposure among both cohorts. However, there was a diversity of exposure to the open-source systems and to the assessment systems. Far fewer Chinese than Australians had exposure to open-source systems such as Maxima, Sage, Octave, GeoGebra and to assessment software. And of the Chinese respondents who had used CAS for teaching in the past, none of them had used open-source systems.

The lack of open-source software usage in China may simply reflect a language issue. Mathematica, Maple, and Matlab all exist in Chinese versions; however open source systems require volunteers to translate both the system and the documentation into other languages. For example, although there exist a number of documents describing Maxima and its use in Chinese, all the examples and screenshots are in English. Figure 2 shows such a screenshot describing Maxima.

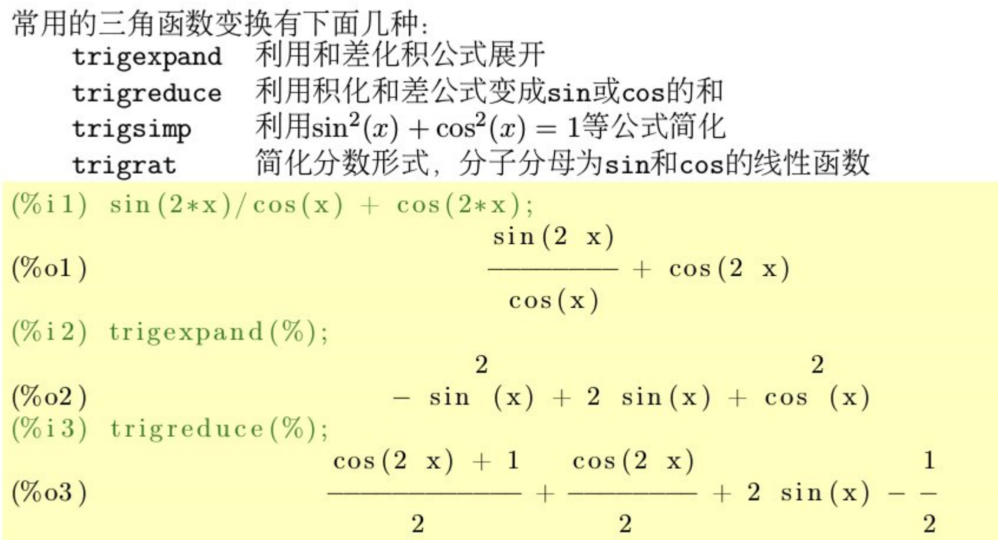


Figure 2: Maxima in Chinese

The explanation is in Chinese, but all the commands are in English. This fact alone is a serious impediment to the take-up of open-source software in China. Maple has long provided language packs in a number of different languages, and currently both the user interface and context-sensitive menus are available in Simplified Chinese, and most of that functionality is available also in Traditional Chinese. Maple TA (the teaching and assessment package for Maple) has had a Chinese language pack since 2010, which makes it all the more remarkable that its take-up, at least as indicated by our survey, appears to be not wide.

There are some open-source software systems with Chinese language packs; for example GeoGebra, shown in figure 3

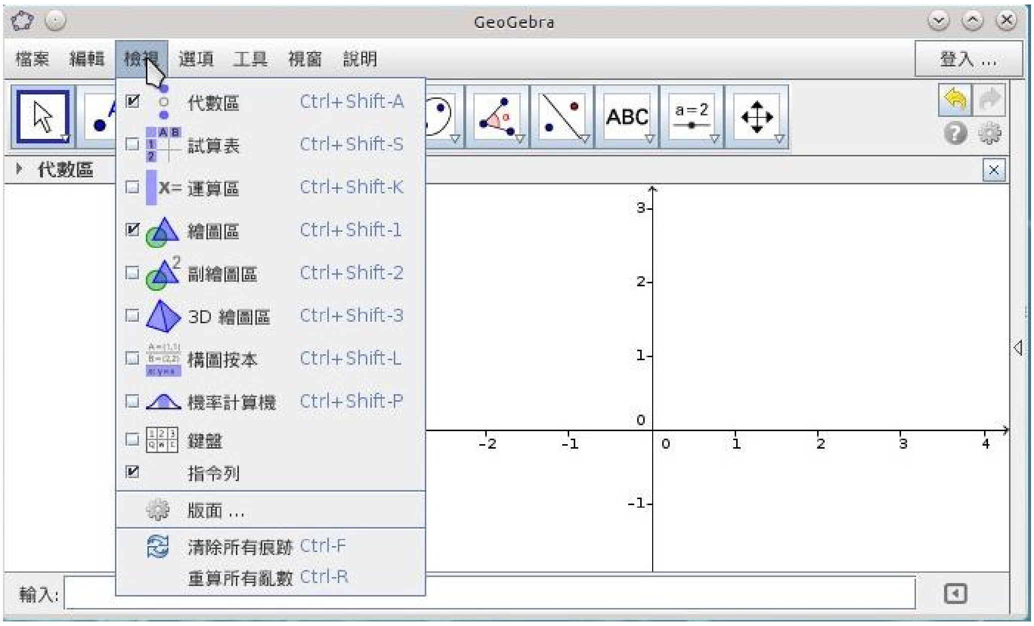
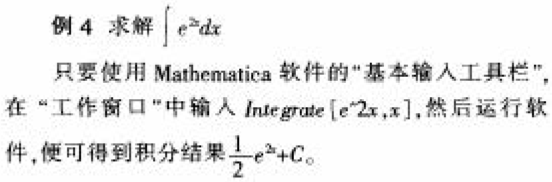


Figure 3: GeoGebra in Chinese

However, even with systems that supposedly have Chinese language packs, information in Chinese is interspersed with the Latin text of the CAS commands, as figure 4, which is taken from a published article, shows.



例 4 求解 $\int e^{2x}dx$

只要使用 Mathematica 软件的“基本输入工具栏”，在“工作窗口”中输入 *Integrate*[e^2x,x]，然后运行软件，便可得到积分结果$\frac{1}{2}e^{2x}+C$。

Figure 4: Discussion of Mathematica in Chinese

There were considerable differences in attitude towards CAS by academics who never used CAS, between the Chinese and Australian respondents. Thirty of the Chinese (50% of the total) and 17 Australians (slightly over 50%) claimed never to have used CAS in teaching. Of those respondents:

- 33% of the Chinese, but only 11% of the Australians, claimed to not have time to learn about CAS.

- 27% of Chinese, but only 11% of Australians, agreed that the use of CAS doesn't prepare students for future mathematical work. This is a belief that flies in the face of much recent research, so we would expect that these people were primarily research mathematicians rather than educators.

- 40% of Chinese, but only 17% of the Australians, claimed not to have time to change the syllabus to include CAS.
- More telling still, over 50% of the Chinese, but only about 11% of the Australians, claimed not to have sufficient support to make CAS available, or to make online assessment available.
- Finally, nearly a quarter of the Chinese, but none of the Australians, chose "Agree" to the statement that "CAS can't be used in assessment, so I don't use it in teaching".

In the final sections, first about mathematical literacy there was one major difference:

- only about 10% of the Chinese respondents felt that CAS enables mathematicians to work more efficiently; whereas over 50% of the Australian thought so.

In the section about attitudes to CAS in teaching:

- over 61% of the Chinese respondents but less than 30% of the Australians believed that CAS encouraged students to examine their solutions more carefully
- about 30% of the Chinese respondents but only about 12% of the Australians believed that CAS usage does not make classes more interesting for students
- 50% of the Chinese respondents but less than 20% of the Australians believed that CAS helps students obtain a deeper understanding of concepts
- nearly 60% of the Chinese, but only 30% of Australians, thought that CAS encouraged collaboration amongst students
- over 35% of the Chinese, and only 16% of the Australians, also felt that CAS does not help students understand mathematical concepts
- over 64% of the Chinese, and only 22% of the Australians, believed that CAS examples improve student attention in class
- over 30% of the Chinese, and only 16% of the Australians, believed that CAS use distracts from understanding mathematical concepts.

These are shown in figures 5 and 6.

These numbers seem at first to be contradictory, but in fact there are several strands here:

1. We have seen that Chinese educators, in general, have had less exposure to CAS than Australians; attitudes from the Chinese would seem to be more idealistic than those from the Australians.
2. In both countries there is a strong opposition to the use of CAS in teaching; based on a notion that the use of CAS is not really "doing mathematics", and that pencil-and-paper drill-and-practice is the only way of properly learning mathematics. As noted previously, the now extensive literature strongly points to the opposite conclusion.
3. Mathematics educators in both countries seem to be coming aware of the important role that technology now plays in mathematical research and practice, however in both countries tertiary mathematics education consists mainly of "covering" a syllabus, and as such is heavily teacher-centred.

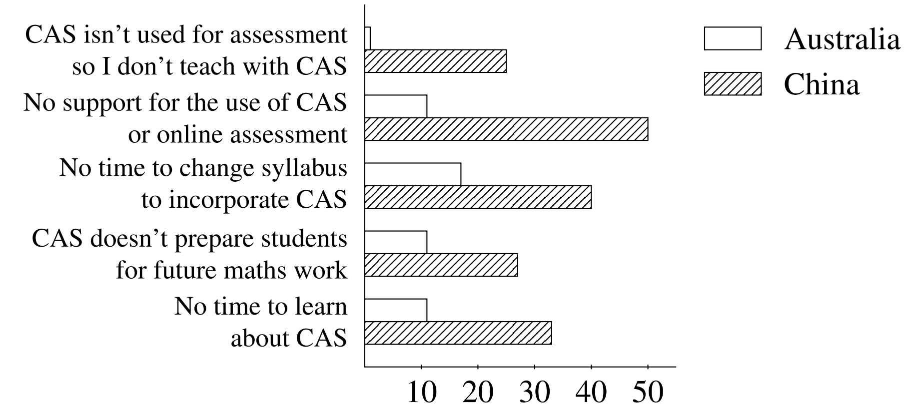


Figure 5: Attitudes to CAS

3 Discussion of the survey

We have seen that there are both similarities and differences between Chinese and Australian attitudes to the use of CAS and other computer systems in educations. Much of the differences seem to come from Chinese lack of exposure to CAS, and to the more prescriptive nature of mathematics education. At a university, a syllabus will be prescribed, and there is little option for a single staff member to amend either the syllabus, or the modes of teaching, or the methods of assessment.

It is worth nothing that Chinese syllabi are in general more prescribed that those in Australian or American universities, where there is greater autonomy. The Chinese Government, through a number of influential and powerful committees, produce guidelines as to the content of mathematics syllabi [5]. Even though they are officially only guidelines, and individual universities or academics may wish to (and occasionally do) teach different material, in practice most teaching at universities follows the guidelines as though they were prescriptive. This environment would appear to make it more difficult for a single academic to radically reform a syllabus, or to change methods of teaching—Chinese

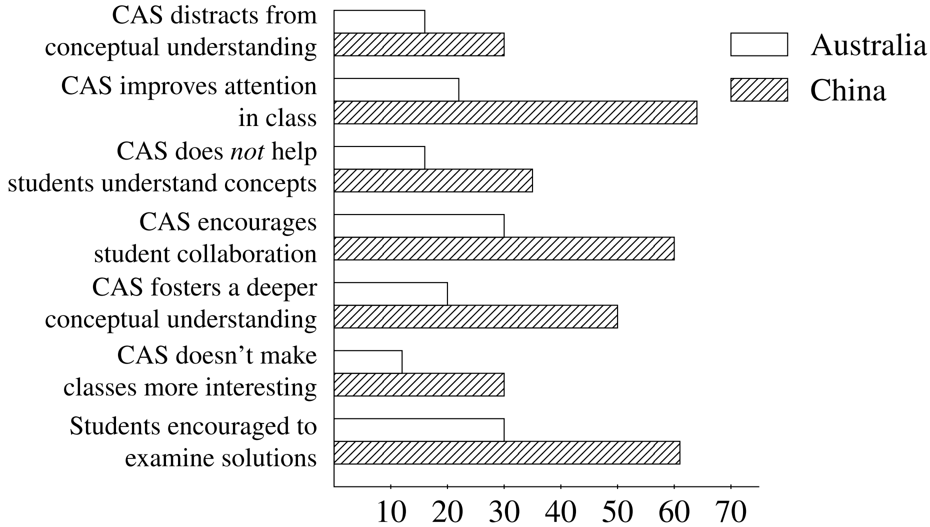


Figure 6: Attitudes to CAS in education

university teaching is predominantly lecture-based, and sometimes students find the transition from secondary school to university difficult.

Curiously, a study some years ago [9] found that Chinese teachers in "lower grades" had more confidence in employing technology than did their US counterparts; the author's interpretation was that Chinese mathematics teachers in lower grades are in general better trained and prepared. Note that technology in the context of this article meant generic technology: AuthorWare, Flash, PowerPoint. The author claimed that Chinese teachers were more keen to use technology for "instruction". There was no indication that teachers would put such technology in the hands of learners.

4 Conclusions

Although there appear differences between the Chinese and Australian attitudes, as evidenced by our survey, the similarities in fact outweigh them. In both countries tertiary mathematics is teacher-centred and syllabus-driven; in both countries the driving force behind most teaching is that of "covering the syllabus"; of "getting through" all the material. This leaves little time for experimentation, and for the use of more student-centred learning models such as problem-based learning, in which one may expect technology to play a major part.

The statistics presented in this paper have been descriptive only; further work will uncover statistical significances, and the degrees to which attitudes in both countries differ.

However, based on the results so far, indications are that academics in both countries have much of the same attitudes: that the use of CAS may well deepen student understanding of mathematical concepts, but there is no room in the syllabi, and little or no local support, for its current use.

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