

## **Developing a Computer Algebra System (CAS) Attitude Scale: A Survey of Pre-service Teachers' Attitudes toward CAS**

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**Abstract:** *Computer algebra systems or software that can manipulate mathematical objects numerically, symbolically and graphically are poised to change the way teachers teach and students learn mathematics. In this paper, to address this change, the development of the Computer Algebra System Attitude Scales, through adapting a widely used computer attitude scale and writing new items, is described. A field test of this instrument in assessing the attitudes of 50 pre-service teachers toward computer algebra system (CAS) upon completion of a CAS-related module requirement of their teacher training programme. The results of the field testing are also discussed.*

### **Introduction**

Over the last two decades, the use of computer technology in enhancing classroom teaching and learning has received much attention from education researchers all over the world (Abbott & Faris, 2000). Among the various computer tools whose usefulness in teaching mathematics has been explored computer software, which can perform exact numeric and symbolic calculations and have attractive graphing capabilities, commonly known as Computer Algebra Systems or CAS's, stand out as having the potential to reshape school mathematics much as electronic calculators have done over the past twenty-five years (NCTM, 2001).

Among the multitude of research studies conducted on computer use in schools, many attitude scales designed to measure various dimensions of computer attitudes have been developed and tested rigorously for reliability and validity (e.g., Gressard & Loyd, 1984). Several of these computer attitude scales have since been compared empirically (e.g., Woodgrow, 1991), used extensively in various contexts (e.g., Koohang, 1987) or adapted to measure other constructs related to computers (e.g., Bolinger, 2000). However, a scale designed specifically for measuring attitudes toward CAS has not been constructed.

The purpose of this study is therefore to report on the development of a CAS Attitude Scale (CASAS) to assess teachers' attitudes toward CAS. The CASAS was developed by adapting a widely used computer attitude scale by Gressard and Loyd (1986) and writing new items. A field test results of the CASAS in which the

instrument was administered to 50 pre-service teachers upon completion of a CAS-related module requirement of their teacher training programme are also discussed.

Development of the CASAS is a strand of a larger study to investigate the effects of integrating CAS into schools in Singapore. The principal study aims to develop a framework for managing curriculum change involving integration of CAS in teaching and learning mathematics in secondary schools by first identifying the key factors that may enhance or impede the change process and then, in the light of the knowledge thus obtained, formulate suitable strategies for managing the change effectively. Note that at present the use of CAS-enabled calculators is prohibited in national examinations in Singapore (Education, 2002).

#### **Rationale**

CAS's have been in existence for more than 20 years and were once used mainly by researchers who had access to powerful and expensive mainframe computers. Today such powerful tools as Derive (see Nash, 1995) and Maple and Mathematica (see Baglivo, 1995) are available on desktop computers and hand-held calculators with user-friendly interfaces at increasingly affordable prices, making CAS accessible even to secondary school students.

Recognising the potential of CAS, particularly CAS-enabled calculators which have an added advantage due to their portability, in shaping mathematics education, many educators and researchers have explored possible uses and effects of CAS in teaching mathematics (as well as physics and engineering courses that draw significantly on mathematical concepts, processes and skills) at tertiary level (e.g., Davis & Fitzharis, 1995; Kennedy & Lennox, 1997) and in teaching secondary or advanced level mathematics (e.g., Aspetsberger, 1996; Schneider, 2000). Other authors have considered pedagogical issues related to the use of CAS (e.g., Kutzler, 2000; Nocker, 1996) and to various other aspects such as curriculum and assessment (e.g., Forbes, 2001; Meagher, 2001).

One of the factors affecting implementation of an educational change is teachers' perception of the efficacy of the change (Fullan, 1991). The teacher is the key to exploiting the potential of CAS in teaching and learning. Awareness of teachers' attitudes toward CAS may provide some insights into teachers' perceptions of and concerns about CAS use in schools, thus help the change manager adopt appropriate strategies and approaches to improve teachers' receptivity to change so as to implement the change successfully. Further, as noted by Woodgrow (1991), assessment of teachers' attitudes toward and knowledge of their experience in using technology such as CAS is critical in managing teacher development. Effectiveness of teachers in using CAS's in teaching is directly related to how well they are able

to use them and learning how to use a CAS takes time. The change manager needs to train teachers in using CAS's and the attitudes of teachers may influence their motivation and interests in learning the new technology. That, in turn, might have a bearing on the effectiveness of the training programmes and hence affect the implementation of the CAS curriculum.

The foregoing discussion amounts to suggesting that there is a need to measure effectively teachers' attitudes toward CAS as well as to seek information on teachers' experience in using CAS. To this end, it is imperative that an instrument such as the CAS Questionnaire be developed, thus taking us one step closer to our objective of establishing a framework for integrating CAS into the secondary mathematics curriculum.

### **Computer Attitude Scales**

#### **Development of GLCAS**

Interest in the study of computer attitudes by researchers started about two decades ago as personal, commercial and office computers took over most of the manual tasks at workplace. Since then, many instruments have been developed to measure various dimensions of computer attitude, rapidly developing an extensive foundation for the study of attitudes toward various different forms of technology (Woodrow, 1991). A common feature among these instruments is that each includes a scale consisting of a set of items which presents statements that purport to investigate certain dimensions of attitudes toward computers.

Many of the instruments developed before 1990 have been tested rigorously for reliability and validity (usually factorial validity) and helped shape their counterparts in the 1990s. Among these instruments, Gressard and Loyd's Computer Attitude Scale (GLCAS) was the most widely used scale, as pointed out by Woodrow (1991). In fact, in a review by Gardner, Discenzas and Dukes (1993), it was concluded that "[GLCAS] is becoming a measure of choice in research on computer attitudes" (p.501). More recently, Francis, Katz, and Jones (2000) concurred that the GLCAS "is one of the most frequently used instruments to assess computer-related attitudes among pre-service and in-service teachers" (p.149) while Myint (2001) described GLCAS as one that "has been used internationally" (p.148) and whose reliability is high based on the many studies that have been done to date.

The original GLCAS was composed of thirty items divided into three subscales: anxiety, confidence and liking and was designed to measure student attitudes toward computers so as to aid schools in evaluating computer-related programmes and in identifying potential problems in implementing curriculum changes (Loyd &

Gressard, 1984). In order to extend the use of GLCAS to measure teachers', and pre-service teachers', attitudes toward computers, a fourth ten-item subscale measuring computer usefulness was added to the original GLCAS by Loyd and Loyd (1985), making GLCAS a forty-item instrument.

In their independent analyses, Woodgrow (1991) and Gardner, Discenza, and Dukes (1993) examined the various scales available and concluded that attitude towards computers is not an explicitly defined term but is broadly used, in the context of the respective studies, to refer to a multi-dimensional construct that encompasses many dimensions. In the case of the GLCAS, the anxiety subscale was constructed because, as seen by Loyd and Gressard (1984), anxiety towards a subject area may influence the learning process, while the liking and confidence subscales were constructed based on the assumption that computer users must be comfortable with and confident in using the computer before they could effectively use them (Loyd & Loyd, 1985). The usefulness subscale was constructed based on the premise that teachers' perception of the usefulness of computers would affect their attitudes toward computers.

#### **Uses of GLCAS**

The usefulness of the GLCAS to managers of teacher development programmes related to implementing computers in teaching becomes evident where, in one study, 15 teachers were administered the GLCAS before and after a staff development programme designed to provide hands-on experience with microcomputers. It was found that the programme lowered anxiety and enhance confidence and liking (Gressard & Loyd, 1985). The findings of a similar study indicated that 70 teachers were significantly less anxious and significantly more confident about computers after their staff development programme (Gressard & Loyd, 1986).

As summarised by Francis, Katz, and Jones (2000), the GLCAS has since been used in studies with school pupils, pre-service teachers and in-service teachers. The GLCAS, for example, has been used in studies among pre-service teachers (Hunt & Bohlin, 1993) and in-service teachers (Loyd & Gressard, 1986). Further, the GLCAS has been translated into Turkish and administered to 282 university students (Berberoglu & Calikoglu, 1993), and into Hebrew where a version of the instrument was developed and tested for reliability and validity (Francis et al., 2000). In a study to validate the GLCAS in the context where English is the second language, the scale was used, without modifications, to determine the attitudes of the teacher trainees toward computers (Myint, 2001). As well, by adapting GLCAS, McFarlane, Green and Hoffman (1998, quoted in Bolinger, 2000) developed the Technology Attitude Survey (TAS) to assess teachers' attitudes

toward numerous technologies rather than just computers. The TAS was later modified by Bolinger (2000) for use with prospective science teachers.

In summary, the GLCAS is a rigorously tested and widely used attitude scale which is internationally accepted and has been adapted to measure various computer-related attitudes. It was therefore decided that an attitude scale for measuring attitudes toward CAS could be constructed by adapting the GLCAS.

### **Development of the CASAS**

The purpose of developing the CASAS was to design an instrument to assess teachers' attitudes toward CAS so as to aid the change manager in formulating strategies for successful implementation of a CAS curriculum.

The resulting CASAS was a three-page research instrument composed of Part I and Part II. Part I was designed to obtain respondents' demographic data such as age group, highest educational level and gender, and information such as number of CAS's the respondents have come across, their experience with learning about or working with CAS, their CAS ownership and their degree of access to CAS. A forty-item attitude scale followed as 'Part II.'

Before Part I, there is a short paragraph which states the purpose of the study and assures the participants that "all responses are kept confidential" and that "it should take about 5 minutes to complete this survey." In Part I, mostly closed questions were used to get direct responses so that analysing the answers is easy and reasonably straightforward. For age, respondents were asked to indicate the age group that applies to them rather than stating their age so that the questionnaire appears less intrusive. Respondents were asked to state their major area of study in addition to indicating their highest educational level, to allow possible correlational study involving educational background. Respondents' experience with learning about or working with CAS and with their CAS ownership is likely to have some influence on their attitudes toward CAS. To obtain further useful descriptive information, respondents were also asked to state the types of CAS they have come across and to describe briefly their CAS experiences.

Part II of the instrument is devoted to the measure of general CAS attitude using an attitude scale. As indicated earlier, the GLCAS is an internationally accepted, rigorously tested and widely used instrument which has also been adapted to measure various computer-related attitudes. The item pool of the CASAS was therefore obtained by mainly adapting items from GLCAS and writing as appropriate some new items. Where necessary, the statements were modified to better suit the scope and local context of our study. This approach is a common in

studies in which computer attitude scales are adapted to assess computer-related attitudes (e.g., McFarlane et al., 1998).

Specifically, in adapting the GLCAS, we first changed the term ‘computers’ in the GLCAS into ‘CAS.’ For example, the item ‘Computers do not scare me’ was reworded into ‘CAS’s do not scare me.’ A total of 16 out of the 40 items thus obtained were retained while another seven were fine-tuned to better suit the local context. To better reflect the nature of CAS, another six items were modified. For example, the item ‘I don’t think I would do advanced computer work’ was replaced with ‘I don’t think I could master advanced CAS skills’ rather than simply changing ‘computer’ to ‘CAS.’ As well, some new items were developed to replace items that were not suitable. For example, the items ‘Generally, I would feel OK about trying a new problem on the computer’ and ‘When there is a problem with a computer run that I can’t immediately solve, I would stick with it until I have the answer,’ were replaced with new items such as ‘I would find it easy to learn how to use a CAS’ and ‘I feel very happy whenever I learn something new about CAS.’ To address usefulness of CAS generally perceived by educators, several new items were also developed for the usefulness subscale. For example, items like ‘CAS’s are good aids to learning’ and ‘Using CAS is a necessary skill for all teachers’ focus on the potential of CAS to be an essential pedagogical tool. Generally, the items are phrased in such a way that CASAS can be administered not only to just mathematics teachers but also to those teaching, say, physics without having to revise the items. CASAS was also designed with a view that it can be adapted easily to measure students’ attitudes toward CAS. See Figure 1 for the forty items in CASAS grouped according to the four subscales.

<b>Anxiety</b>
1. CAS’s do not scare me at all
5. Working with a CAS would make me very nervous
9. I do not feel threatened when others talk about CAS’s
13. I feel aggressive and hostile toward CAS’s
17. It wouldn’t bother me at all to be trained to use CAS
21. CAS’s make me feel uncomfortable
25. I would feel at ease attending a CAS training course
33. I would feel comfortable working with a CAS
29. I get a sinking feeling when I think of trying to use a CAS
37. CAS’s make me feel uneasy and confused

<b>Confidence</b>
2. I'm no good with CAS's
6. I would find it easy to learn how to use any CAS
10. I don't think I could master advanced CAS skills
14. I am sure I could be good at CAS's
18. I'm not the type to be good at CAS's
22. I am sure I could master a CAS
26. I think using a CAS would be too difficult for me
30. I could teach myself to use any CAS
34. I do not think I would be in complete control when I use a CAS
38. I have a lot of self-confidence when it comes to working with CAS's.
<b>Liking</b>
3. I would enjoy working with CAS's
7. The challenge of exploring CAS use in teaching does not appeal to me
11. I think working with CAS would be interesting and stimulating
15. Being good at CAS's would not make me happier
19. I feel very happy whenever I learn something new about CAS
23. I don't understand how some people can spend so much time working with CAS and seem to enjoy it
27. Once I start to work with a CAS, I would find it hard to stop.
31. I will do as little work with CAS as possible
35. If there is a course on CAS that is new to me, I would definitely attend
39. I do not enjoy talking with others about CAS working
<b>Usefulness</b>
4. I can use CAS's many ways in teaching
8. Learning about CAS is a waste of time
12. CAS's are good aids to learning
16. I'll need a firm mastery of CAS in time to come
20. I expect to have little use for CAS in my daily work
24. I can't think of any way that I will use CAS
28. Knowing how to use a CAS is a necessary skill for teachers.
32. Anything that a CAS can be used for, I can do just as well some other way
36. It is important to me to be a skilled CAS user
40. Working with CAS will not be important to me in my work

*Figure 1.* Items from the CASAS

Though a total of 11 items are new, the structure of the GLCAS, in that the 40 items are sequenced in a particular way according to the subscales they measure and whether they are positively or negatively worded, was preserved so as to maintain the psychological stability of the scale. In particular, positively and negatively worded items in each of the four subscales remained equal in number; that is, five positive and five negative items for each subscales, giving it 40 in all. To shuffle the items and to include items worded in a reverse way helps prevent respondents from seeing a pattern in the responses and modifying their responses in the light of this.

As in the case of the GLCAS, the CASAS uses a four-point Likert scale to preserve the essence of GLCAS as far as possible. To obtain the score for each item, each category on the rating scale is assigned a number (“strongly disagree”=1; “disagree”=2; “agree”=3; “strongly agree”=4). The total score is derived from the sum of the individual item scores after reversing the scores for negatively worded questions. Thus the higher a score the more positive is that person's attitude.

The CASAS thus developed was then shown to two education researchers in the United Kingdom, one of whom specializes in use of information and communication technology in education, to confirm the face validity of the instrument. The instrument was then refined in the light of the comments given.

#### **Survey of Pre-service Teachers' Attitudes toward CAS**

To field test the CASAS, the instrument was administered to a group of 50 pre-service teachers to measure their attitudes toward CAS. The study compared male and female teachers' scores, and mathematics majors' and non-mathematics majors' scores, on the four subscales and the entire score.

The 50 pre-service teachers who responded to the CASAS had completed a one-semester (66 hours) core module on teaching secondary mathematics taught by the author. The module included a component on use of CAS in teaching which required the pre-service teachers to attend five two-hour sessions weekly in a computer laboratory and to design a worksheet for teaching a mathematical concept using a CAS of their choice. CAS's used in the module include Maple and hand-held algebraic calculators. Assessment of the worksheet constituted 20% of the assessment of the module.

All the 50 respondents (23 female, 27 male) were university graduates, the majority of which were in their 20's (92.0%); just one of them was over the age of 40. Half were mathematics majors, while engineering graduates made up another 34%. The rest were physics majors. Among the 50 pre-service teachers, 22 of them had at



least three months of formal teaching experience in a secondary school either as a relief teacher or a contract teacher.

The internal reliability indices, alpha coefficients, were adequate for all the four subscales and the entire scale. Using individual scores as unit of analysis, the reliabilities were 0.821 (Anxiety), 0.774 (Confidence), 0.859 (Liking) and 0.831 (Usefulness). The reliability for total score was found to be 0.921.

The mean, standard deviations, minimum and maximum scores of each subscale of CASAS are presented in Table 1. The pre-service teachers scored highest on the anxiety subscale (30.62 out of a possible score of 40), followed by the usefulness subscale (29.78), the confidence subscale (28.90) and the liking subscale (27.06). As the higher the score, the more positive the respondent's attitudes toward CAS, the results imply that pre-service teachers, in general, were not anxious towards using CAS and tended to appreciate the potential usefulness of CAS.

Table 1  
*Statistics on Subscale Scores and Total Score*

	Anxiety	Confidence	Liking	Usefulness	Total
Mean Score	30.62	28.90	27.06	29.78	116.36
Std. Deviation	4.33	4.02	5.14	4.09	14.01
Minimum Score	23	21	16	22	91
Maximum Score	40	37	39	38	152

Table 2 presents the Pearson correlation coefficients between each of the four subscales and the whole scale. The correlations between the subscales range between 0.405 and 0.757 and are significant at 1% level. All of the four subscales are highly correlated to the total score with the correlation coefficients ranging between 0.751 and 0.862 which are of similar magnitudes to those found in a number of studies using the GLCAS (e.g., Loyd & Loyd, 1985). These results lend further support to the reliability of the instrument. Interestingly, there is a higher correlation between 'CAS liking' and perceived 'CAS usefulness' than between 'CAS confidence' and perceived 'CAS usefulness'.

The study found that male pre-service teachers have higher mean scores in anxiety, confidence and usefulness subscales as well as the total score, albeit marginally, as an application of the t-test showed that the differences are not statistically significant at the 1% level (see Table 3). Female pre-service teachers in the study

Table 2  
*Intercorrelation among subscales and whole scale*

Scale	Anxiety	Confidence	Liking	Usefulness	Total
Anxiety	--	.540**	.453**	.415**	.751**
Confidence		--	.466**	.405**	.743**
Liking			--	.757**	.862**
Usefulness				--	.814**
Total					--

\*\* Correlation is significant at the 0.01 level (2-tailed).

Table 3  
*Mean Scores by Gender*

Scale	Gender	Mean	Std. Deviation	t Score
Anxiety	Male	31.93	4.07	2.424
	Female	29.09	4.20	
Confidence	Male	29.37	3.94	0.895
	Female	28.35	4.12	
Liking	Male	27.22	4.74	0.239
	Female	26.87	5.68	
Usefulness	Male	29.44	4.19	-0.624
	Female	30.17	4.03	
Total	Male	117.96	12.67	0.875
	Female	114.48	15.51	

appear to appreciate more of the usefulness of CAS though again the difference is not significant at the 1% level. Gender differences in computer attitudes have been reported in many studies and findings suggest that males are more enthusiastic about using computers and more confident in using them (e.g. Woodrow, 1991). The results from this study are similar to the findings in most of these aspects.

An analysis of the scores by subject major shows that the math majors scored higher in all the four subscales and the whole scale as compared to the non-math majors but none of these differences is statistically significant based on a t-test at 1% level. This result came as no surprise as the non-math majors comprise physics

majors and engineering graduates and, as we mentioned earlier, CAS's are as widely used by physicists and engineers as are used by mathematicians. The results of the t-tests are presented in Table 4.

Table 4  
*Mean Scores by Subject Major*

Scale	Subject Major	Mean	Std. Deviation	t Score
Anxiety	Math	31.04	4.5505	0.682
	Non-math	30.20	4.1433	
Confidence	Math	29.00	4.0620	0.174
	Non-math	28.80	4.0517	
Liking	Math	27.84	5.0471	1.074
	Non-math	26.28	5.2243	
Usefulness	Math	31.00	3.6515	2.188
	Non-math	28.56	4.2139	
Total	Math	118.88	14.2575	1.281
	Non-math	113.84	13.5637	

### Conclusion

This paper has reported on the development of the 40-item CASAS for measuring the attitudes of teachers toward CAS by adapting the widely used GLCAS and writing new items. In field testing the instrument, the CASAS was administered to 50 pre-service teachers'. The results provide evidence that the instrument is reliable given the high Cronbach alpha coefficients obtained for the subscales and the entire scale of CASAS. Further analyses of the data also revealed that pre-service teachers of different gender and different subject major did not show any statistical differences on their attitudes toward CAS. Note, however, that owing to the same sample size, these results should be viewed as preliminary, not definitive.

Further, measuring attitude is generally difficult and inferring attitude from expressed opinion has limitations. Even though attitude scales provide for anonymous response, people may conceal their true attitudes and express more socially acceptable opinions (Oppenheim, 1992). However, notwithstanding the limitations of Likert-type attitude scales discussed above, as what is needed is a means to measure general CAS attitudes efficiently, it suffices to adapt a well-established scale such as the GLCAS so that our study could tie in with previous literature on GLCAS.

It might also be questioned whether or not the CAS attitudes and computer attitudes are different psychological phenomenon. It would be interesting to study whether or not CASAS and GLCAS are of similar factor structure by investigating the correlation between the two scales.

Indeed, many studies involving the CASAS could tie in with previous literature on GLCAS such as replicating previous studies on computer attitude scales and investigating whether parallel findings can be derived. It should be qualified that prior to doing that, validity and reliability of the instrument must be tested rigorously with different groups of pre-service and in-service teachers teaching mathematics or subjects that require substantial use of mathematics. The CASAS can also be easily revised for assessing students' attitudes toward CAS.

Ultimately, future research on the CAS Questionnaire should be conducted with a view to demonstrating that the construct of CAS attitudes has a position in respect of other computer-related constructs. As for the present study, the CAS Questionnaire provides an effective means to assess teachers' attitudes toward CAS so as to aid change managers in identifying professional development needs of the teacher so that effectiveness of the subsequent teacher development programme can be evaluated efficiently.

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