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Students' Attitudes towards Handheld Computer Algebra Systems (CAS) in Mathematics: Gender and School Setting Issues

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Abstract: This paper reports on a recent research study which investigated Victorian year 10–11 mathematics students' attitudes and beliefs on the impact of handheld CAS calculators on students' mathematics achievement. Students were surveyed using the Mathematics and Technology Attitudes Scale (MTAS), which was used to monitor five affective variables relevant to learning mathematics with CAS. Principal Component Analysis (PCA), t-tests, correlations and MANOVA were used for the analysis of responses. The results of students' responses indicated that there is a positive correlation between their attitudes towards CAS and their prior knowledge and experience. The results also reflected the common finding that boys express greater confidence than girls in technology use in mathematics learning.

Key words: CAS, students' attitudes, mathematics learning

1. Introduction

The aim of the study was to investigate year 10–11 mathematics teachers' and their students' attitudes and beliefs towards the impact of handheld CAS calculators on students' mathematical outcomes in relation to gender. This paper focuses only on the students' beliefs.

Computers, graphing calculators and handheld CAS calculators have been used in secondary schools for the learning of mathematics in Australia and overseas for more than two decades. Their use has been supported and advocated through schools' mathematics curriculum and government initiatives (AAMT, 1996; NCTM, 2000; VCAA, 2005, 2007). Burton and Jaworski (1995, cited in Vale, 2002, p. 202) expressed concern that the use of computers and other technologies in mathematics might erode advancements made toward gender equity in mathematics. Furthermore, Vale (2002, p. 203) claimed that the research about gender and computers illustrates the concerns raised by mathematics education researchers about the cultural influence of computers in mathematics and hence the need to carefully examine what is happening for girls in these learning environments. Also, the research into mathematics teachers' and students' attitudes and beliefs about teaching and learning contexts established a series of systematic associations linking teachers' attitudes and approaches with their students' attitudes, learning approaches, and outcomes (Prosser & Trigwell, 1999).

An explanation of these associations is therefore important in understanding the significance of investigating mathematics teachers' and their students' attitudes and beliefs of teaching and learning using handheld CAS calculators in mathematics classrooms. Handheld Computer Algebra Systems (CAS) calculators are currently

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mandatory in senior secondary mathematics classrooms in Victoria (Australia). Thus, it is becoming important for educators and mathematics teachers to know students' perceptions, if they want students of both genders to be more successful in mathematics classes. The purpose of the study reported in this paper was to investigate students' attitudes and beliefs about handheld CAS calculators in mathematics learning and to determine if males' and females' views differ.

2. Literature Review

The brief review of the literature that follows explores the studies and findings of previous research on gender differences in mathematics outlined by Ruthven (1995), Fennema (2000), Forgasz (2002) and others on their analysis of gender and technology in mathematics education.

A major goal of the research on gender issues in relation to technology is to increase our understanding of how gender differences develop and relate to technology in mathematics. However, with regard to gender and technology, the small number of studies, particularly those addressing Victorian secondary mathematics students, gave conflicting results to students' attitudes towards computers and graphics calculators.

Previous research studies on gender differences showed how different ways and methods have been used to minimise the gender gap, not only in mathematics teaching, but also in many fields of study especially in science, engineering and technical fields.

Much research focused on students attitudes' towards mathematics tended to influence their performance in the subject as well as their future careers involving mathematics (Clifford, 1998; Fennema, 2000). Also, the interactive nature of technology could provide the opportunity for girls especially, to work independently and become more confident in learning of mathematics.

In her study focussing on gender and attitudes towards computers in mathematics learning, Forgasz (2002) found that:

> Compared to males, females are generally reported to be less positive about computers, like them less, perceive them as less useful, fear them more, feel more helpless around them, view themselves as having less aptitude with them, and show less interest in learning about and using computers; females are also less likely than males to stereotype computing as a male domain, to have received parental encouragement, to use computers out of school or to own one. (p. 369)

However, research on graphing calculators by Ruthven (1995) found that the performance of upper secondary female students using graphing calculators was clearly superior to that of their male counterparts on items that required visual-spatial abilities. Similarly, Forster and Mueller (2001) suggested that girls are not disadvantaged in mathematics, as often suggested, where the use of graphing calculators is an integral and important part of the teaching and learning and when assessment questions and tasks are completed using graphing calculators.

In Victoria, the 2006–2009 Mathematics Study Design (VCAA, 2005) further extends the use of CAS in the other Units, 3 and 4 subjects, allowing handheld CAS calculator into the assessments of Further Mathematics, Mathematics Methods (CAS) and Specialist Mathematics. This introduction and implementation of CAS calculators has resulted in change to existing curricula, assessment and teaching styles because it challenges the algorithmic algebra and graphing that form the central thread of secondary mathematics (Asp & McCrae, 2000). As mathematics classes in Victoria are on the cusp of a new era in handheld CAS calculators, it seemed reasonable to research mathematics teachers' and their students' beliefs and attitudes towards the impact of handheld CAS calculators on teaching and learning mathematics and on the mathematics curriculum, particularly in the Victorian context.

To conclude, some of the literature presented here suggested that with regular calculator use male and female students show significant improvement in their mathematical understanding and skills when dealing with mathematical problems. However, this is dependent on the nature of their experiences, including the classroom culture and the teaching and learning activities set by their mathematics teachers.

3. Research Method

The participants were 520, Year 10–11 students, from 15 Catholic secondary schools across Victoria. Invitations to participate in this research were sent to 85 coeducational, and single-sex Catholic secondary schools in Victoria. There were 268 (51.5%) students from metropolitan and 252 (48.5%) students from non-metropolitan Catholic schools. Of the 15 schools that participated in the study, three were from high, six from medium, and six from low socioeconomic areas.

In order to investigate the relationship between the students' mathematics confidence, confidence with handheld CAS calculator, attitude to learning mathematics with CAS calculators, affective engagement and behavioural engagement, achievement, gender and year level, the Mathematics and Technology Attitudes Scale (MTAS) (Pierce, Stacey & Barkatsas, 2007, p. 299) was administered. Five subscales were developed by Pierce et al. (2007, p. 299), which allowed the researchers to monitor the following five variables:

(1) Mathematics confidence (MC): Students' perceptions of their ability to attain good results and their assurance that they can handle difficulties in mathematics.

(2) Affective engagement (AE): How students feel about mathematics.

(3) Behavioral engagement (BE): How students behave when learning mathematics.

(4) Confidence with CAS technology (TC): Students' confidence in using handheld CAS calculators.

(5) Attitude to the use of CAS technology to learn mathematics (MT): Students' interaction with CAS.

These variables were selected because they were constructs required to measure students' competence and confidence when using handheld CAS calculators in the mathematics classroom. The instrument consists of 20 items. A 5-point Likert-type scoring format was used for each of the subscales listed above. Students were asked to indicate the extent of their agreement with each statement, on a five point scale from strongly agree to strongly disagree (scored from 5 to 1). A different but similar response set was used for the Behavioural Engagement (BE) subscale. Year 10–11 students were asked to indicate the frequency of occurrence of different behaviours. A five-point system was again used-Nearly Always (NA), Usually (U), About Half of the Time (Ha), Occasionally (Oc), Hardly Ever (HE), (scored from 5 to 1).

A t-test was used to determine any differences that existed between boys' and girls' responses.

4. Data Analysis and Discussion

4.1 Factor Analysis

The twenty survey items of the MTAS were initially subjected to a Principal Component Analysis (PCA-extraction method: Maximum Likelihood), using SPSS Version 18.0. The five components that were extracted were identical to the five components of the original MTAS by Pierce et al. (2007): *Mathematics Confidence [MC], Confidence with Technology [TC], Attitudes to Learning Mathematics with Technology [MT], Affective Engagement [AE], and Behavioural Engagement [BE]*. Prior to performing the PCA, the suitability of data for a PCA was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin sampling adequacy value was .87, exceeding the recommended value of .6, and the Bartlett's Test of Sphericity was statistically significant (< .001), supporting the factorability of the correlation matrix (Pallant, 2009, p. 197).

The PCA using data from 520 students' responses to the twenty items forming the MTAS indicated that the data satisfied the underlying assumptions of the PCA and that together Principal Component analysis revealed the presence of five components with eigenvalues greater than 1, explaining 29.7% (component 1), 15.3% (component 2), 7.9% (component 3), 6.9% (component 4) and 5.4% (component 5) of the variance respectively. An inspection of the scree plot revealed a clear break after the fifth component. The five components that were extracted were identical to the five factors of the original MTAS survey Pierce et al. (2007), and those reported by Barkatsas, Kasimatis and Gialamas (2009).

4.2 Reliability Analysis

Reliability analyses yielded satisfactory Cronbach's alpha values for each subscale of (MTAS) indicating a strong or acceptable degree of internal consistency in each subscale. The lowest value was that of the MConf subscale (0.69), however, according to Hair, Anderson, Tatham and Black (2006), the generally agreed upon lower limit for Cronbach's alpha is 0.70, although it may decrease to 0.60 in exploratory research.

5. Further Statistical Analyses

In order to explore gender differences in the set of dependent variables, a multivariate analysis of variance (MANOVA) was conducted. Five dependent variables were used (MC, TC, MT, AE, and BE). The independent variable was gender. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity, with no serious violation noted (Wilk's Lambda = .88, $F(5, 177) = 4.57$, $p < .001$). There were statistically significant differences between males and females in two subscales TC ($p < .05$) and MC ($p < .05$). Gender differences are examined in the next section.

5.1 Gender Differences

This section reports results on the five subscales by gender. Only responses from the six Catholic coeducational schools are considered in this section, in which the boys and girls have experienced the same mathematical learning environments. One hundred and eighty four (87 boys and 97 girls) completed all the items of the survey. Background characteristics of the student sample are listed in Tables 1 and 2 below.

Table 1 Students' Characteristics by Gender in Coeducational Schools

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	87	47.3	47.3	47.3
Female	97	52.7	52.7	100.0
Total	184	100.0	100.0	

Table 2 Students' Characteristics by Year Level in Coeducational Schools

	Frequency	Percent	Valid Percent	Cumulative Percent
Year 10	42	22.8	22.8	22.8
Year 11	142	77.2	77.2	100.0
Total	184	100.0	100.0	

The breakdown of these scores by gender, illustrated in Figure 1 below, revealed that boys have statistically significantly higher scores than girls for subscales TC ($t = 2.78$, $df = 180$, $p < .01$) and MC ($t = 3.01$, $df = 180$, $p < .01$) indicating significant gender differences. No statistically gender differences were found for the BE ($t = -.657$, $df = 182$, $p = .512$), MT ($t = .044$, $df = 182$, $p = .965$) and AE ($t = .25$, $df = 182$, $p = .801$) subscales. These results reflect the common finding that boys express greater confidence than girls in technology and mathematics, as shown in the respective MC and TC distributions of scores in Figure 1, and are similar with those of Pierce et al. (2007) who found gender differences on variables corresponding to TC (Confidence with Technology) and MC (Mathematics Confidence), and less difference on variables MT (Attitudes to the use of CAS technology to learn mathematics) and AE (Affective Engagement).

As reported earlier, *no* statistically significant differences were found for the BE subscale. These results contrast with those of Vale and Leder (2004) who found gender differences only on their variable corresponding to MT. They found that boys view computer-based mathematics lessons more favourably than girls. Vale and Leder (2004) viewed students' attitudes to computer-based mathematics as being defined by the students' perceptions of their achievement in mathematics. They noted differences in boys' and girls' behaviors in mathematics lessons when computers were used: "girls viewed the computer-based learning environment less favorably than boys and boys and girls thought differently about the value of computers in their mathematics lessons" (Vale & Leder, 2004, p. 308).

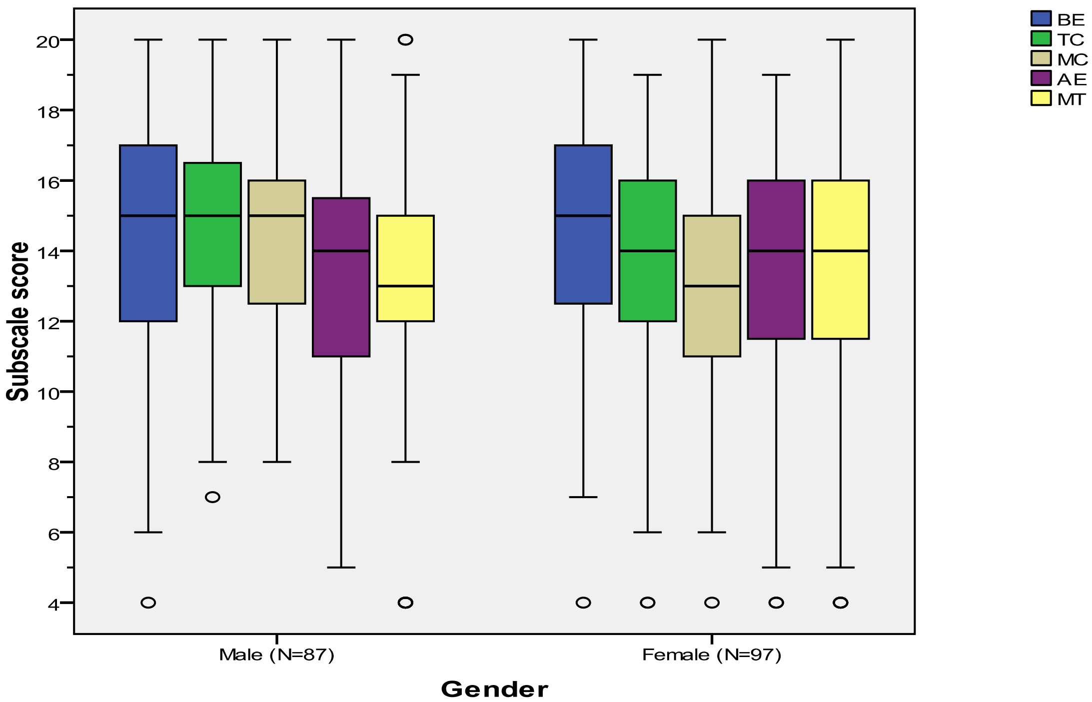

Figure 1 MTAS Scores for Subscales by Gender

5.2 School Setting Differences

This section reports results on the five subscales by students' school type. Responses from the nine (4 single-sex boys, and 5 single-sex girls) schools are considered in this sections. Three hundred and thirty six students (145 boys and 191 girls) completed all the items of the survey.

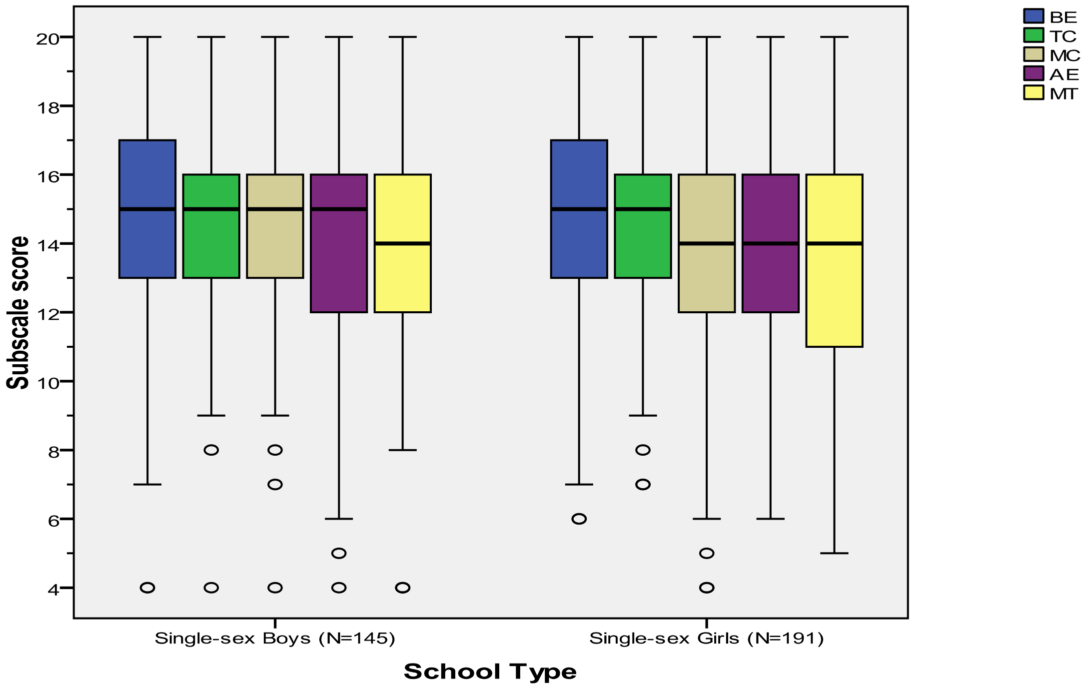

Figure 2 MTAS Scores for Subscales by School Type

As shown in Figure 1 above, the median, the upper quartile and the maximum value in the MT distribution of scores for girls are all greater than the respective values in the boys' MT distributions of scores, indicating that not all the students with negative attitudes for learning with CAS are girls, and that boys and girls valued using CAS in mathematics lessons. The breakdown of the scores by school type, illustrated in Figure 2 above, revealed that single-sex boys' schools have statistically higher scores than single-sex girls' schools for the MC and the AE subscales. No significant differences between single-sex boys' schools and single-sex girls' schools were found for the BE, TC, and MT subscales.

6. Conclusions

In this paper we investigated Victorian secondary students' attitudes towards handheld CAS calculators in mathematics learning. The *Mathematics and Technology Attitudes Scale* (MTAS) was used to examine student engagement, attitude, and confidence in learning mathematics with CAS.

The findings revealed that there are statistically significant positive correlation (weak, moderate or strong) between all parts of scales BE, TC, MC, AE, and MT for males and females for the 184 students from the six Catholic coeducational schools. We have two explanations for this positive correlation: (1) there is a strong tendency for year 11 girls and boys who felt confident about mathematics and to value using handheld CAS calculator for learning mathematics; and (2) boys and girls are experiencing the learning of mathematics more positively, simply because the use of handheld CAS calculators is currently mandatory in years 10 and 11 in all Victorian Catholic secondary schools, and students value it because they feel it has the potential to compensate for self-perceived shortcomings (Pierce et al., 2007).

The results of the study also indicated that boys in single-sex boys' schools were more confident about their ability to attain good results and also could handle difficulties in mathematics (MC) better than girls in single-sex girls' schools. However, no differences were found in students' confidence in using handheld CAS calculators (TC) or attitudes to the use of CAS technology to learn mathematics (MT). These results are similar to those reported by Forgasz (2008), who analyzed the VCE mathematics results for 2007. Forgasz revealed a clear pattern of male dominance among the highest achievers in all of the subjects examined, and the proportions of high achieving males far exceeded their proportions of enrolments in the various subjects. The study also revealed that students in single-sex schools, particularly in boys' schools, were highly over represented among the highest achievers in all three VCE mathematics subjects.

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References

Asp G. and McCrae B. (2000). "Technology-assisted mathematics education", in: K. Owens and J. Mousley (Eds.), *Research in Mathematics Education in Australia 1996–1999*, Sydney: MERGA, pp. 123–160.

Australian Association of Mathematics Teachers (1996). *Statement on the Use of Calculators and Computers for Mathematics in Australian Schools*, Adelaide: AAMT.

Barkatsas T., Gialamas V. and Kasimatis K. (2009). "Learning secondary mathematics with technology: Exploring the complex interrelationship between students' attitudes, engagement, gender and achievement", *Computers and Education*, Vol. 52, pp. 562–570.

Clifford H. (1998). *A Comparison of Gender Related Attitudes towards Mathematics Between Girls and Boys in Single Sex and Coeducational Schools*, Exeter, UK: University of Exeter.

Fennema E. (2000). "Gender and mathematics: What is known and what do I wish was known", available online at: http://www.wcer.wisc.edu/nise/News_Activities/Forums/Fennemapaper.htm.

Forgasz H. (2008, July). "Gender, school settings, and high achievers", Paper presented at *Topic Study Group 32, ICM-11*, Monterrey, Mexico, available online at: http://tsg.icme11.org/document/get/157.

Forgasz H. (2003). "Girls, boys, and computers for mathematics learning", in: B. Clarke, A Bishop, R. Cameron, H. Forgasz & W. T. Seah (Eds.), *Making Mathematicians*, Brunswick, Vic: Mathematical Association of Victoria, pp. 346–361.

Forgasz H. (2002). "Computers for learning mathematics: Gender beliefs", in: A. D. Cockburn & E. Narda (Eds.), *Proceedings of the 26th Conference of the International Group for the Psychology of Mathematics Education*, Vol. 2, Norwich, UK: PME, pp. 369–375.

Forster P. A. and Mueller U. (2001). "Outcomes and implications of students' use of graphics calculators in the public examinations of calculus", *International Journal of Mathematical Education in Science and Technology*, Vol. 32, No. 1, pp. 37–57.

Hair J. F., Anderson R. E., Tatham R. L. and Black W. C. (2006). *Multivariate Data Analysis* (6th ed.), Prentice Hall International, Upper Saddle River, NJ.

National Council for Teachers of Mathematics (NCTM) (2000). *Professional Standards for Teaching Mathematics*, Reston, VA: Council for Exceptional Children.

Pallant J. (2009). *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows* (Version 15, 3rd ed.), Allen & Unwin. Crows Nest, NSW.

Pierce R., Stacey K. and Barkatsas T. (2007). "A scale for monitoring students' attitudes to learning mathematics with technology", *Computers and Education*, Vol. 48, pp. 285–300.

Prosser M. and Trigwell K. (1999). *Understanding Learning and Teaching: The Experience in Higher Education*, Philadelphia, PA: Society for Research into Higher Education & Open University Press.

Ruthven K. (1995). "Pressing on", in: L. Burton & B. Jaworski (Eds.), *Technology in Mathematics Teaching: A Bridge between Teaching and Learning*, Lund, Sweden: Chartwell-Bratt, pp. 231–256.

Vale C. (2002). "Girls back off mathematics again: The views and experiences of girl in computer-based mathematics", *Mathematics Education Research Journal*, Vol. 14, No. 3, pp. 202–218.

Vale C. and Leder G. (2004). "Student views of computer based mathematics in the middle years: Does gender make a difference?", *Educational Studies in Mathematics*, Vol. 56, No. 3, pp. 287–312.

Victorian Curriculum and Assessment Authority (2007). *CAS Technology Mathematics at Level 6 Victorian Essential Learning Standards (VELS)*, Part 2: CAS technology, a brief background, East Melbourne: VCAA.

Victorian Curriculum and Assessment Authority (2005). *Mathematics. Victorian Certificate of Education Study Design*, Units 1–4, 2006, 2009, East Melbourne: VCAA.