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# Calculator Technologies and Females' Mathematics Learning: A Pilot Study

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## Abstract

The aim of this study was to begin to investigate whether a relationship existed between females' attitudes to calculator technology and their achievement and participation in higher-level mathematics. The sample size was small. However, the results show that most of the participants believed that technologies such as graphics and Computer Algebra System (CAS) calculators are obstacles to learning higher-level mathematics and did not enable a better understanding of mathematical concepts to be gained. The females in this study did not find mathematics useful and relevant in their lives except as a vehicle for university entry. This finding invites further research on a larger scale.

## Introduction

The Victorian Certificate of Education [VCE] is one of the senior secondary school qualifications registered in Victoria (Victorian Curriculum and Assessment Authority, 2009). It is normally undertaken over a two-year period; Units 1 and 2 are equivalent to Year 11 while Units 3 and 4 are equivalent to year 12, the final year of secondary schooling in Australia. Students undertaking VCE Units 3 and 4 have a choice of mathematics subjects. Further Mathematics is the easiest of the mathematics subjects; Mathematical Methods and Mathematical Methods Computer Algebra System [CAS] follow with respect to difficulty, and Specialist Mathematics is the highest-level mathematics subject offered at this level. For each subject there are three assessment components: two examinations, and one school-assessed task.

Recent research by Forgasz and Tan (2010) raised possible consequences related to the impact that the utilisation of newer calculator technologies may be having on females who choose to study in higher-level mathematics in the VCE. They found that for both Mathematical Methods (in which graphics calculators are used) and Mathematical Methods CAS (in which CAS calculators are used), a higher proportion of males received the A+ grade for the school-assessed task and for examinations 1 and 2. In both of these subjects, Examination 1 consists of a number of short answer and some extended answer questions and has been technology-free since 2006 while Examination 2 includes multiple choice and extended answer questions and calculator use is mandated. They also found that for each assessment task, the gender gap favouring males was greater for Mathematical Methods CAS than it was for Mathematical Methods. In addition, they established that the gender gap favouring males was widest for the A+ grade in examination 2 of Mathematical Methods CAS.

Prior to the research of Forgasz and Tan (2010), Forster and Mueller (2001) raised concerns related to the participation of females in technology-dominated mathematics subjects:

> [The] significant decline in the numbers of female students [in mathematics] has occurred at the same time as the use of technology in the curriculum has increased, so the question must be asked if the two changes are related. (p. 51)

Since then, the Mathematical Association of Victoria [MAV] (Mathematics Association of Victoria, 2003) presented data from a literature review (by Vale) related to technology use in mathematics. According to the Mathematics Association of Victoria (2003), Vale had found that the introduction of increasingly sophisticated technology in mathematics was likely to

favour males and could lead to lower achievement and enrolments of girls in VCE Mathematics. As a result of findings such as those raised by Vale (Mathematics Association of Victoria, 2003) and Forgasz and Tan (2010), the focus of the current research was on beginning to investigate whether the utilisation of graphics or CAS calculators played a role in the lower participation rates of females in higher-level mathematics, and whether a relationship existed between females' attitudes towards such technologies and their mathematics participation. These concerns provided the rationale for the study and guided the development of the research questions. One of the aims of the study was to identify if, as suggested by the earlier research, calculator technologies do indeed put females at a disadvantage with respect to mathematics study.

**Aims**

Within a general liberal feminist framework (Babbie, 2007), the aims of the present study were to investigate whether the utilisation of calculator technologies encouraged or discouraged a small group of females from participating in VCE Units 3 and 4 Mathematics, and whether this utilisation inhibited or extended their mathematical knowledge and impacted on their decision to move into tertiary level studies of mathematics or mathematics-related courses.

**Methods and survey instruments**

In the current research study, a questionnaire that included both closed and open questions was administered in an attempt to garner more detailed responses to participants' attitudes to VCE mathematics and calculator technologies. The survey utilised in this study was adapted from the questionnaire described by Forgasz (2003).

**The sample**

Participants consisted of nine individuals who were recruited using a convenience sample. Initial approaches for participation were made by email to a group of young women who had been tutored by the first named researcher in VCE Units 3 and 4 English in recent years. In total, nine completed questionnaires were returned and all participants had completed VCE between 2005 and 2008. Five participants had undertaken some studies in mathematics at VCE level; one had undertaken studies in Further Mathematics, four had completed Mathematical Methods; none had enrolled in Mathematical Methods CAS or Specialist Mathematics. Four participants had not undertaken studies in Units 3 and 4 Mathematics. The returned questionnaires were divided into two groups; those from participants who had not undertaken any VCE Units 3 and 4 Mathematics studies (MathsN), and those from participants who had undertaken Mathematics studies (MathsY).

Descriptive statistics (frequencies and percentages) were used in the data analyses. Because sample sizes were small, for items with Likert-type response formats, the categories of 'strongly agree' and 'agree' were collapsed into the 'agree' category for ease of interpretation; similarly, the categories of 'strongly disagree' and 'disagree' were collapsed into the 'disagree' category. The category 'neither agree nor disagree' was renamed 'unsure'. Caution has been taken in interpreting the results. Due to the low number of participants, trends observed could not be generalised, but may serve to provide directions to guide future research.

**Results and Discussion:**

**The participants**

Background data were gathered in the questionnaire administered to the participants. In all, there were nine female participants and all were from Melbourne's Western and Northern suburbs. All were aged between 18 and 21 and had completed the Victorian Certificate of Education between 2005 and 2008. Most had attended Catholic secondary schools (7), and all but two were undertaking full time tertiary study at the time the data were collected. Pseudonyms will be used when referring to particular participant's responses.

**Calculator use and mathematics learning**

In Table 1, participants' responses to items related to calculator use and the learning of mathematics are presented. These items were designed to canvas participants' views of how the utilisation of calculator technologies influenced their ability to understand mathematics.

Table 1

*Calculator Use and Learning Mathematics*

| No. | Item | Studied VCE Mathematics (MathsY) | | | Did not study VCE Mathematics (MathsN) | | |
|---|---|---|---|---|---|---|---|
| | | Agree | Unsure | Disagree | Agree | Unsure | Disagree |
| 20 | Graphics/CAS calculators are an obstacle to learning higher-level mathematics. | 3 | 1 | 1 | 3 | 1 | 0 |
| 16 | When using a graphics/CAS calculator, it was more important to be able to do a procedure than it was to understand the mathematics behind it. | 3 | 0 | 2 | 3 | 1 | 0 |
| 26 | I found learning to use a graphics/CAS calculator easier than learning mathematical concepts. | 1 | 1 | 3 | - | - | - |
| 30 | I have a better understanding of mathematical concepts as a result of using a graphics/CAS calculator. | 2 | 0 | 3 | - | - | - |

**Calculators as obstacles to learning mathematics**

As seen in Table 1, the view that graphics/CAS calculators were an obstacle to learning higher-level mathematics (item 20) was held by three (of 5) MathsY and three (of 4) MathsN participants. This is of interest as the data appear to conflict with the contention of some researchers that the utilisation of graphics/CAS calculators allows students to gain a better understanding of mathematics (e.g., Leigh-Lancaster, Evans & Norton, 2003; Hornaes & Royrvik, 2000). Participants were provided with the opportunity to explain their reasons for holding this belief. Although Charlotte, a MathsY participant, stated "I don't think it's an obstacle, I see it as another method of doing mathematical problems," most participants disagreed. Asha, another MathsY participant, responded with a view commonly held by participants:

> I believe that the calculators can be an obstacle to higher-level maths. This is because I think that studying higher level implies that the maths is more advanced, and if advanced equations are placed into calculators, then the students wanting to excel their mathematical skills will not be able to do so, because it will primarily be the calculator working.

Jessica, a MathsN participant (who had undertaken Units 1 and 2 General Mathematics) stated:

> The graphics calculator is an obstacle because you have to know all the buttons and remember them for an exam.

The fact that Asha believed that the calculator was doing much of the work suggests that she may have thought that she was not an active participant in finding answers when she was using a calculator. Even though Holland (2006) states "the notion that the calculator is doing all of the mathematics is simply not true" (p.11), it appears that some of the participants in this study disagreed with this sentiment.

**Procedure vs. understanding**

Most of the participants from both the MathsY (3 out of 5) and MathsN (3 out of 4) groups agreed that when using a graphics/CAS calculator, it was more important to be able to do a procedure than it was to be able to understand the mathematics behind it (see Table 1, item 16). Agreement with this statement is concerning with respect to mathematical understanding. The opinions on this item may be partially attributable to the participants' prior experiences of the teaching styles adopted by their mathematics teachers. Although not

specifically stated, the participants' teachers may have influenced this belief. If the teachers had made substantial efforts to ensure that students were not simply pushed to remember and replicate procedures, such views may not have been expressed. Unfortunately, due to a crowded curriculum and high stakes examinations at the grade 12 level, teachers may feel that they are forced to teach to examination content at the expense of students' mathematical understanding.

When asked if they found learning to use a graphics/CAS calculator easier than learning mathematical concepts, only two (of 5) MathsY participants agreed (see Table 1, item 26). As stated by Roberts (2005), "judging by the recent history of mathematics courses, calculators always get bigger and more expensive" (p. 8) and, it seems, more bewildering for students. When asked to elaborate, Asha, a MathsY participant, explained that learning to use the calculator was "a bit harder than learning maths concepts, as there were quite a few functions that were available on the calculators." Jessica, a MathsN participant, believed that "it was harder because [the calculator] just gave the answer without the explanation." Claire, a MathsY participant, believed that "it is easier to use a CAS calculator because you learn the steps as you go visually rather than a mathematical concept,"; this reinforced the idea that students may be learning procedures for generating answers with very little understanding of what they are actually doing.

**Learning mathematical concepts**

When asked if they had a better understanding of mathematical concepts as a result of using a graphics/CAS calculator, three MathsY participants disagreed and two agreed (see Table 1, item 30). The fact that three participants did not feel that the use of the calculator provided them with a more thorough understanding of mathematical concepts appears to contradict the contention of the majority of participants that students were advantaged by having to use graphics/CAS calculators. The responses appear to show that the advantages provided by such calculator technologies (namely, the ability to generate answers quickly) may be outweighed by the fact that participants may not have much understanding of the mathematical concepts behind the calculations.

**Usefulness of mathematics**

In Table 2, MathsY and MathsN participants' views on the usefulness of mathematics in their lives and whether it was only useful for those seeking university entry.

Table 2
*Usefulness of mathematics*

| No. | Item | Studied VCE Mathematics (MathsY) | | | Did not study VCE Mathematics (MathsN) | | |
|---|---|---|---|---|---|---|---|
| | | Agree | Unsure | Disagree | Agree | Unsure | Disagree |
| 7 | I believe that VCE Mathematics is useful for those who undertake it. | 3 | 2 | 0 | 4 | 0 | 0 |
| 9 | VCE Mathematics is only useful for those seeking university entry. | 4 | 0 | 1 | 0 | 2 | 2 |

When asked if they believed that VCE Mathematics was useful for those who undertake it, three (of 5) MathsY participants and all four MathsN participants agreed (see Table 2, item 7). In contrast, an interesting difference is seen in the responses obtained from participants to the statement that VCE Mathematics is only useful for those seeking university entry (item 9). Four (of 5) MathsY participants agreed with this, while no MathsN participants agreed; two MathsN participants disagreed whilst the other two were unsure.

Four (of 5) MathsY participants believed that mathematics was only useful for those seeking university entry. This may serve to explain why they enrolled in grade 12 mathematics subjects, despite their belief that the use of graphics/CAS calculators was an obstacle to learning mathematics. Seemingly contradictory results were presented in Table 2. It was seen that two (of 5) MathsY participants were unsure whether VCE Mathematics is useful for those who undertake it (item 7). If this view is more widespread, further explorations as to why students may feel this way are needed.

Several of the participants in this study did not appear to find any real use for VCE mathematics in their lives. This appears consistent with Willis' (1989) claim that "as they proceed through secondary schooling, girls become less convinced that mathematics is personally useful" (p. 28). If the disconnection that participants in this study appear to have with higher-level mathematics is representative of the views of females in general, it may be one factor that contributes to the decline in females' (and males') participation in VCE mathematics (VCAA, 2001; 2008).

In Table 3 the views are presented of MathsY participants as to why they chose to undertake VCE Mathematics, and whether they believed that their participation had given them relevant skills and knowledge. They were also asked if they regretted undertaking VCE Mathematics. As seen in Table 3, when MathsY participants were asked why they chose to undertake VCE Mathematics, three responded that they believed it would be useful for them and they needed it for university entry (item 34). Even though the results presented in Table 3 show that three (of 5) MathsY participants believed that VCE Mathematics was useful for those who undertake it, four (of 5) MathsY participants did not believe that their participation provided them with relevant skills and knowledge (Table 3, item 41). In addition, three of them regretted doing mathematics (see Table 3, item 42). It may be that those who did not regret their participation in VCE Mathematics had this view because taking the subject had assisted them in being accepted into a university course. This is supported by the responses provided by some MathsY participants. Annika explained "I do not regret doing VCE maths as it allowed me to get into my course", while Claire stated "I regret doing VCE [mathematics] because it was not a prerequisite for my course and I have not used it since". This provides further support for the results presented in Table 2 that VCE Mathematics was seen by participants as only useful for those seeking university entry. That four MathsY participants, all of whom are currently studying at university, did not see their experiences in VCE Mathematics as useful or relevant is worrying; if the broader student community holds the same view, it may be a factor that begins to explain the decrease in higher-level secondary mathematics enrolments currently being observed in Australia (Barrington, 2009).

Table 3

*Reasons MathsY participants (n=5) studied mathematics*

| No. | Item | It is an interesting subject | I thought it would be useful for me | The use of calculators made mathematics easier | I had done well in Units 1 and 2 mathematics | I needed it for university entry | Other |
|---|---|---|---|---|---|---|---|
| 34 | I chose to undertake Units 3 and 4 VCE Mathematics because:* | 0 | 3 | 0 | 1 | 3 | 0 |
| 41 | | | Yes | | | No | |

| | | | |
|---|---|---|---|
| | Having taken VCE Units 3 and 4 Mathematics, do you believe your participation has given you skills and knowledge that are relevant to you right now? | 1 | 4 |
| 42 | I regret doing VCE Mathematics. | 2 | 3 |

* Participants were able to choose more than one response

The reasons why MathsN participants did not take VCE mathematics subjects are shown in Table 4. They were asked whether their non-participation had limited their relevant skills and knowledge. They were also asked if they regretted not undertaking VCE Mathematics. As can be seen in Table 4, when asked why they chose not to undertake VCE Mathematics, three (of 4) MathsN participants stated that they did not need it for university entry (item 46). It can also be seen that three participants did not feel that their non-participation had limited their skills and knowledge (item 47) and they held no regrets about not taking VCE Mathematics (item 48).

Responses shown in Tables 3 and 4 raise concerns regarding participants' views on the usefulness of mathematics in their lives. It is clear that these participants did not consider mathematics to be a subject that would provide them with useful skills. Jessica, a MathsN participant, stated:

> The girls who undertook VCE Maths Units 3 and 4 were under so much stress due to the graphics calculator. I will never regret not doing maths as it was too complicated and did not give me skills for my career or life.

This statement seemed to sum up the view of many of the participants in this study. Should this view be more widespread, then concerns related to calculator utilisation and student participation (particularly that of females) in higher-level mathematics need to be taken seriously in the educational community.

Table 4
*Reasons MathsN participants (n=4) did not study VCE mathematics*

| No. | Item | I did not need it for university entry | I found the subject too difficult | It was not useful for my future employment aspirations | I was dissatisfied with my school's mathematics teachers | Other |
|---|---|---|---|---|---|---|
| 46 | I chose not to undertake Units 3 and 4 VCE Mathematics because:* | 3 | 1 | 1 | 1 | 0 |
| | | | Yes | | No | |
| 47 | Do you believe that your non-participation has limited your skills and knowledge that may be of | | 1 | | 3 | |

| | | | |
|---|---|---|---|
| | assistance to you right now? | | |
| 48 | I regret not doing VCE Mathematics. | 1 | 3 |

* Participants were able to choose more than one response

As seen in Table 4, three MathsN participants stated that one reason they did not undertake VCE Units 3 and 4 Mathematics was because they did not need it for university entry (item 46). Of these participants, all are current university students. Another statement from Jessica demonstrates the overall view of many participants:

> VCE maths did not provide me with any knowledge that I need now because it has no use in daily life.

A response by Claire supports this view. She stated that "the majority of what [she] learnt in Year 12 maths [she has] never used or thought about again," and Annika stated that she did not think she has "had to use VCE maths much since the end of Year 12."

As explained by Willis (1989), "the different participation rates of boys and girls in mathematics indicate quite clearly that its use as a filter for a wide range of occupations is insufficient at present to convince girls to participate to the same extent as boys" (p. 29), especially when it appears that non-participation may not prevent them from entering or being successful at university. It seems apparent that very little has changed in the twenty years since Willis raised these concerns. Although some of the participants of the current study may have deliberately chosen courses that did not require mathematics, it may still be the case that "we should question efforts to convince girls to study mathematics on the basis of improved job prospects" (Willis, 1989, p. 34). In contrast to Willis (1989), Jones and Smart (1995) asserted that "this is a political issue as mathematics is a 'gatekeeper' [that allows] access to a range of opportunities [and] girls are excluding themselves from these opportunities by choosing not to continue with their mathematical studies" (p. 164). Even though this claim may still be true, it appears that the possibility of limiting prospects was not critical in the decisions of the participants in the present study to opt out of higher-level mathematics study.

**Conclusion**

The results of this small study raise a number of concerns with respect to the views that females may have toward the use of graphics and CAS calculators in VCE Mathematics, as well as their general opinions on participation in VCE Units 3 and 4 Mathematics. Although these results have been interpreted with caution due to the small sample, a number of trends were identified which may, if present in the larger student community, raise alarm with respect to the impact that graphics/CAS calculators may have on the participation and achievement of females in higher-level mathematics study. Further research with larger samples is needed to determine if any of these trends are supported.

Consistent with the findings of Forgasz and Tan (2010), the results of this small study suggest that the utilisation of calculator technologies may be discouraging females from participating in VCE Mathematics. It was seen among this small group that most believed that the use of calculator technologies did not extend their mathematical knowledge and that graphics/CAS calculators were obstacles to higher-level mathematics learning. Although several felt that the speed at which answers could be generated when using calculator technologies was an advantage, most believed that the calculators did not make mathematics easier for them.

Participants' views of the usefulness of mathematics influenced their decisions whether to participate in VCE Mathematics or not. Several believed that VCE Mathematics was only useful as a vehicle for university entry. Many of those who undertook VCE Mathematics did not feel that their participation provided them with useful skills and knowledge.

**Directions for future research**

The views and opinions of only nine females about calculator technologies and mathematics were examined in this study. Further explorations are warranted to discover if these perceptions are more widespread. If the views of participants in this study mirror the consensus of females in Victorian schools, the continued downward trend in female participation in higher-level mathematics may persist and affect their potential to be involved in mathematics-related careers.

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