

Matching the Hatch – Students’ Choices and Preferences in Relation to Handheld Technologies and Learning Mathematics

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This paper reports on students’ choices of and preferences for different hand held technologies when provide with options within a classroom that integrates technology into the teaching and learning of senior secondary school mathematics. Observations were drawn from video and audio data as well as a whole class interview of the focus group in which the video of a previous lesson was used for stimulated recall. This report notes a number of emergent categories of student preference and choice based on this data and comments on the potential impact of such choices and preferences on student learning.

Introduction

We have moved, over the past five years, to a state where the use of higher end technologies, such as graphing calculators or computers with mathematically enabled softwares, is either mandatory, or at the very least, access is assumed, for the teaching, learning and assessment of mathematics, within the post compulsory years of secondary schooling, in seven out of Australia’s eight states and territories. This is evident in curriculum frameworks and study designs (for example Queensland Board of Senior Secondary School Studies 1992, 2000; Victorian Board of Studies 1999). At the same time, the developing availability of this type of technology has also brought with it, at least in some schools, a divergence in the technology available to students to engage in learning mathematical ideas and processes. While there is now a significant body of knowledge, in relation to the use of technology in the teaching, learning and assessment of mathematics, in general, there is also a limited literature base related to the issue of students’ choices of technological options when learning or doing mathematics. This paper seeks to extend knowledge in this domain through the analysis of interviews that targeted students’ preferences when a choice of graphics calculators, with different levels of functionality, are (IS) available. A number of classes of preference emerge from the analysis.

Literature Review

Advocates for the transformation of school mathematics classrooms into technology rich environments have argued that the use of technology in teaching/learning offers: the promise of better learning outcomes (Vonder Embse, 1992; Portafoglio, 1998; Weber, 1998); the potential to offer more varied approaches to instruction (Dance, Nelson, Jeffers & Reinthaler, 1992); and enhanced student/student and student/teacher interaction in mathematics classrooms (Burrill 1992; Geiger and Goos, 1996; Galbraith, Renshaw, Goos and Geiger, 1999). Further, Kutzler (1999) has argued that mathematically enabled technologies have the potential to scaffold student learning in such a way that gaps in prior

learning can be managed so that they do not interfere with the acquisition of new mathematical ideas and concepts. Overall findings, however, concerning the “value adding” to students’ learning through the use of technology have been somewhat inconclusive (Penglase & Arnold, 1996; Kuchler, 1998; Maldonado, 1998). Despite mixed conclusions reported in these reviews, it has been noted by Asp and McCrae (2000) that this is merely indicative of the need for further research in this area.

An area that has received little attention to date is that related to the choices students make when they have the opportunity to select from more than one type of technology, and what processes they engage when making decisions about how to best match available technologies with the mathematical task at hand. Geiger (1998) explored the issue of students making use of technology in different modes, for example, to work through computationally intense tasks quickly, to explore an unfamiliar situation or to enhance collaborative work with others. This theme was further developed by Galbraith, Goos, Renshaw and Geiger (1999), who provide a sociocultural perspective on teaching and learning mathematics in technology rich environments by identifying categories of student expertise - *Master, Servant, Partner and Extension of Self* - based on the way in which graphing calculators, or other mathematically enabled technologies were used. While these studies indicate that students are aware that they make use of available technology in different ways they do not explore the issue of making use of different technologies. Their findings are suggestive, however, of preferences to work with technology in different ways, which in turn should lead to different choices being made when provided with the opportunity to match their mathematical needs with a choice of different technologies. While our earlier theorising has drawn substantially from Vygotskian notions of the ZPD, Valsiner (1987) has described two additional zones of interaction, the Zone of Free Movement (ZFM) and Zone of Promoted Action (ZPA), that can help to account for the activities that students pursue in learning contexts. According to Valsiner (1987), the ZFM represents environmental constraints that limit freedom of action and thought, For students in secondary mathematics classrooms. elements of the ZFM might include:

1. perceived abilities that may constrain teaching actions and hence learning opportunities;
2. curriculum and assessment requirements, which influence choice of topics and teaching methods;
3. resources, in the form of teaching materials, computers or calculators, or specially equipped rooms;
4. the time available to teach required content;
5. the images that students hold about what mathematics is, and what constitutes mathematical activity.

While the ZFM suggests which learning actions are *possible*, the Zone of Promoted Action (ZPA) represents the efforts of a teacher to *promote* particular teaching skills or approaches. Our interest here is in the ways that students initiate and sustain the use of technology in a classroom where the students' ZFM is subjected to the fewest possible constraints, while the ZPA encourages a maximum use of available devices.

The Study

Classroom Context and Data Source

This study took place within an independent, coeducational secondary school in the state of Queensland. This paper seeks to describe one aspect of a larger two-year study which aim(ED) to investigate the teaching/learning practices of students and teachers in senior secondary school mathematics courses in relation to the use of technology. This

paper describes preferences and behaviours that emerged when students used technology to investigate and solve a combinatorics problem which was part of a course designed for tertiary bound students with aspirations for further specialist studies in mathematics or related disciplines. The 15 students (5 female, 10 male) were in their final two years of study and were typically 16 – 17 years old and by nature of their choice of subjects generally displayed a positive disposition to the study of mathematics.

There are no restrictions on the form of educational technology that students are allowed to employ in the learning, teaching or assessment of mathematics in the school based curriculum framework within which this study is embedded. It had become a matter of policy, in the school involved in this study, that technology be integrated into student learning experiences whenever it is appropriate and possible. The type of technology utilised ranged from computers equipped with mathematically enable(D) applications through to graphics calculators. The student group that is the focus of this paper made use of two types of graphics calculator. These are listed below with a brief outline of the features available on each device:

TI-92 Calculators (Texas Instruments)

1. Graphical, numeric representations of functions
2. Statistical capabilities
3. CAS capabilities - including matrix editor and complex number manipulation
4. Dynamic geometry module

TI-83 Calculators (Texas Instruments)

5. Graphical, numeric representations of functions
 6. Statistical capabilities
- Matrix editor and complex number manipulation

Students in this group also displayed a positive predisposition to the use of technology (Galbraith, Renshaw, Goos and Geiger, 2001). A student statement, taken from a class survey, in relation to the use of technology in the learning of mathematics, illustrates the enthusiasm displayed by students in relation to the use of technology in the mathematics classroom

Because my calculator has become my best friend. His name is Wilbur. Me and Wilbur go on fantastical adventures together through Maths land. I don't know what I'd do without him. I love you Wilbur.

While it might be suggested that this statement is a little tongue in cheek, there are sufficient other corroborating comments from students to confirm that the essence of the above statement was a prevalent attitude.

The data sources for this project consisted of: audio and video records of classroom observations; individual, group and whole class structured and semi-structured interviews; and questionnaires. The data on which this particular paper is based were drawn from three 45 minute lessons spaced over a two week period. These lessons were video taped, and the dialogue subsequently analysed.

Teaching Episodes and Observations

A Problem in Combinatorics

The style of teaching/learning in the focus classroom had a problem solving orientation. Topic or concept sequences generally began with a problem that was judged to

be of a level of challenge just removed from what students could address procedurally. The aim of this approach was to provoke the exploration of the idea and as a consequence to stimulate discussion of the idea rather than simply provide instruction that led to content acquisition.

This paper reports on a series of episodes that were initiated when students were asked to solve the combinatorics problem below:

$${}^n C_3 = \frac{5}{18} {}^n C_5 \quad \text{Find } n$$

Students were observed to use both types of available calculators to assist them to investigate and solve the problem but it was also noted that they took different approaches to how they made use of a chosen device. This session was video and audio taped for later use with the class.

Student Revelations

The next day students were shown video segments of the whole class working on the combinatorics problem from the previous lesson in order to stimulate students' recall about their observed behaviours during the taped session. A whole class interview was conducted to gain insight into what students believed were the reasons for these decisions. Approximately one week after this session, students undertook a course work focused assessment task. During this assessment task it was again noted that students were using different calculators and using them in different ways. A second whole class interview was conducted during the next available lesson in relation to the students' use of calculators during assessment. Four categories of calculator use emerged from the two discussion sessions.

Getting to Know You: Some students commented that they preferred to use one calculator over another simply because they used it more often (eg in other courses) and were more familiar with its operation. While this is not a surprising result, familiarity with a device has a greater effect than a willingness to use it. One student commented that the TI-83 was a more efficient device for typing in instructions which preferenced their selection toward this model, unless they needed any of the specific facilities of the TI-92 that were unavailable on the TI-83. This directly contradicts the preference of a different student who felt the TI-92 calculator offered more direct access to the commands via the qwerty keyboard than the TI-83. In both cases the students' level of familiarity and expertise with their chosen device allowed them to focus on how to use the device as efficiently and effectively as possible. This was despite the fact that they had chosen different devices for the same reason!

Teacher. But Stephen, why would you have picked the 83 rather than the 92

S1. Because I don't think there is anything more the 92 could have done that the 83 couldn't have...

Teacher. So Stephen, the idea, what you are telling me is that unless you really need the facilities of a 92 you'd prefer to use the 83?

S1. Yeah.

Teacher. Is there any reason why...that you prefer to use it?

S1. Well it types faster.

Other students

S2. 'cause we use it (TI-83) more often, it's easier to know where all the functions are

S3 We're used to it.

Teacher. Whoa, whoa...let's slow down.... So you think the nice thing about the 92 ...'cause you (talking to Student D) tend to use it as a first preference, don't you, is that because you know the command you can just type in and do things straight away, whereas on the 83, you have to go through the menus to get the commands?

Student agrees.

Matching the Hatch: Students were asked directly why they choose one calculator type over another (TI-83 vs TI-92). One student argued that you should only use technology as powerful as is needed for the task at hand

Other students indicated that the choice of calculator depended on the task and the particular device's suitability to that task.

G. Well it depends on what kind of work you're doing...with permutations and combinations, I find it easier on this (signalling TI-83) but with complex numbers and things (another student adds matrices) yeah, matrices - it's so much easier on the 92.

In fly fishing terms they were saying you should "match the hatch" – choose the tool that is most appropriate for the prevailing conditions and environment.

This attitude was taken to the extreme by some students who used both calculators on a particular task – matching sub-tasks with the particular facilities of each calculator based on perceived suitabilities to the job they were attempting to complete.

S4. Whenever I was doing normal calculations, I'd use the little one because I could look at my matrix and do the calculations at the same time, that sort of thing.

Teacher. You're using both at once because...

S4. By then, you could see the matrix really clearly on the big calculator

Teacher. You use that as just a way of looking at it, but you do all the manipulation on the other one.

S4. Well I like using the big one for complicated stuff like "i" and stuff like that, but the little one is just easier to use when you are doing all that little basic stuff.

The Look: Students also commented on differences between the way the calculators displayed certain inputs and outputs. They indicated a preference for a visual display that might be considered closest to how mathematics is written with a pad and pen, or when properly type set. They found this more useful for checking their inputs and looking for mistakes.

S5. It (the TI-92) gives you what you typed in. It actually writes out the matrices you are multiplying together instead of giving just "a" or "b".

Teacher. Okay, so you can see it...you like seeing the matrix, not just a symbol for it?

S6. Visually this (the TI-92) is a bit better.

Lean on Me: Students were also asked to comment on their choice of methods when solving the combinatorics problem that had been the focus of the initial lesson. The responses were varied and ranged from “trial and error” approaches using the basic arithmetic facilities of either calculator, through to methods which required a more sophisticated understanding of the capacities of their chosen device such as the “equation solver”. As part of this discussion the teacher sought clarification on what a particular student (absent on the day of the interview) was observed to be doing on the video. Students working with her replied as part of the interchange below:

Teacher. You know what she (N – absent student) was doing E.

S9. She was expanding

Teacher. So she (E) wasn't solving like D, she was expanding using it like an “Algebra Assistant”. She was using it as a way of checking her algebra.

S9. She used it to *do* her algebra

This student appears to have used the calculator as a means to “scaffold” her way around an area of mathematics in which she may lack confidence – algebra – so that she can still address the problem she was asked to solve. The student that replies to the question makes it clear that student E was using the TI-92 to do her algebra not merely to check work she had completed with pen or paper. This was confirmed with a follow up question to student E when she returned to class. She indicated that she would have been far less confident about finding a solution if had to rely on her own algebraic skills without the assistance of the calculator.

Discussion

The observations categorised above indicate that students will not only make different choices when provided with options in the range of technologies they can access when working on mathematics but they also base these choices on individual preferences and perceptions about a device's suitability for a task.

While familiarity with a particular device is an important influence on the choices students made about which calculator they used, they were prepared to override established preferences when they could clearly see that another calculator offered a more efficient or effective means to complete a task. This was most strongly evident in students who were observed to use two calculators while completing a single task. These students still like to have the calculator they were most comfortable using as a default but made use of the alternative device when they inferred that the specifics of a sub-task demanded the use of facilities that were only found, or were best implemented, on the alternative device. For example, a number of students commented on how they preferred to work with matrices on the TI-92 rather than the TI-83 and would change to this calculator whenever making use of matrices.

Students also reflected on the differences between visual displays when making a choice between calculators. A number of students commented on the importance of seeing the whole of their input or expected outputs while working with a calculator. They felt less comfortable in working with a problem or detecting errors when some part of the input or output was off screen because of the length of the input or output. Further, students also expressed a preference for displays that represented mathematics in a similar fashion to the

way they wrote it - with a pen on paper, or how it appeared in a book. Clearly they found unfamiliar styles of symbolic representation at best distracting and at worst less intelligible. Thus the "visual" aspect of students' interaction with mathematics and technology should not be underestimated.

It was observed that at least one student made use of the CAS capabilities of one the calculators to support her use of an algebraic approach to solving the combinatorics problem. This illustrates the potential that exists for CAS technology to provide the scaffolding needed by students who are less proficient with algebra to access other aspects of mathematics. Further work is needed in this area to determine the potential support this technology offers students, who are less proficient in terms of traditional algebraic capabilities, to find success in other type of mathematics.

The four different categories of calculator use identified indicate that students moved comfortably within a technology ZFM within which they did not feel constrained to a set of 'approved' methods. This was particularly evident within the 'match the hatch' category, with different preferences not only selected but articulated and defended.

Conclusion

While students clearly indicated preferences for using a particular calculator from those available, these choices were influenced by a balance between familiarity with a particular device and the students' perception of a match between the demands of the task and facilities available on different devices. Thus students' predispositions and expertise with particular devices has the potential to influence how they learn and do mathematics within technology rich classroom environments.

It would appear that the provision of choice has allowed students to match their needs as learners with particular facilities offered by the different devices. This can range from what might appear to be a superficial preference for the way inputs and outputs are represented on a screen, as was the case for a number of students in relation to working with matrices, through to the opportunity to scaffold around areas of mathematical weakness such as the case of the student who used the CAS facilities of a TI-92 to deal with her lack of confidence in her algebra skills. It is perhaps also worth reflecting on the potentially negative effects of a mismatch between the needs of the learner and the technology available in situations where only a limited choice is possible.

If the influence of student learning orientations and preferences in relation to choice of technologies is as influential as is suggested here then there is clearly a need to further investigate, identify and delineate such effects in classrooms that integrate the use of technology into the learning of mathematics. In terms of theoretical structuring the ZPA provides a conceptual framework for structuring and presenting opportunities for the creative and productive use of technology in learning mathematics. Application of ZFM notions then provides a reality check that conditions in a classroom are indeed consistent with teaching intentions and opportunities for learning. Taken together with reasonable expectations of performance (students' ZPDs) the respective zone frameworks provide a basis for a self-consistent and challenging design of teaching approaches, learning contexts, and performance criteria for technology enriched classrooms.

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