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Abstract: Although the majority of our primary school teacher education students enter with a positive attitude to mathematics, their understanding of mathematics is challenged in a problem solving and investigative subject. The subject involves the use of computers. It is a challenge to keep them positive about ICs and mathematics while challenging their beliefs. The students who are not so positive and have difficulties with either the mathematics or the technology need support. This paper looks at the support that is provided and the outcomes of the subject. One successful focus has been on the links between their understanding of mathematics, its application in a community project and their role as a future primary school teacher. Another has been the nature of the computer laboratory classroom learning experiences.

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Although the majority of our primary school teacher education students enter with a positive attitude to mathematics, their understanding of mathematics is challenged in a problem solving and investigative subject. The subject involves the use of computers. It is a challenge to keep them positive about ICTs and mathematics while challenging their beliefs. The students who are not so positive and have difficulties with either the mathematics or the technology need support. This paper looks at the support that is provided and the outcomes of the subject. One successful focus has been on the links between their understanding of mathematics, its application in a community project and their role as a future primary school teacher. Another has been the nature of the computer laboratory classroom learning experiences.

Introduction

There have been a number of studies establishing how Information and Communication Technologies (ICTs) can enhance the learning of mathematics (see, for example, review by , 2000). Interacting with the computer provides students with an opportunity to be engaged in experimenting and drawing on knowledge in a dynamic environment. Nevertheless, “representations need anchoring in student’s physical, imagistic, emotional experiences … [Furthermore, the value of ICT representations may be limited if] the mutual constitution of meaning for not only the notations and links among them, but for the phenomena and situations that they may be used to model, is insufficiently rooted in authentic student experience.” (Kaput, 1996, p. 21 & p. 22). If other aspects of the learning environment are supportive then students should develop more complex knowledge schema of mathematical content and have a background for developing sound pedagogical content knowledge (Chinnappan, 2003). Supportive environments establish appropriate problem solving strategies and provide problems that are within the grasp of the students’ knowledge (McClain & Cobb, 2001).

Studies indicate that the computer or graphics calculator acts as a focus for discussion between students and thus encouraging deeper understanding (Chinnappan, 2003; Martin & Pirie, 2003; Pierce & Stacey, 2001). Nevertheless, Martin and Pirie (2003) point out that for students to move on from image making to property noticing and then generalising, it may be necessary for the teacher to provide examples that assist with their image making in order to move forward again after setting themselves a new investigation. They point out, as other studies have done (see, for example, Penglase & Arnold’s review, 1996), that using ICTs may also limit learning.

Outline of the Teaching Subject

The first subject that our primary school teacher education students attempt is called Numeracy and Technology. This subject considers the foundations of numeracy by
examining the purposes of mathematics in the community. Students explore mathematics as an enjoyable way of making meaning. It utilises the framework “working mathematically” as a vehicle for acquiring concepts. This subject also introduces students to the use of technology both as a personal tool for study and as a medium for learning. Students learn to use educational media effectively as an aid to concept acquisition.

The subject develops students’ ability to

- use modern technology for information retrieval and processing, data manipulation and analysis, and communication
- continue to develop intellectually and utilise new learning for changing career needs

The subject encourages in students an appreciation of

- the values of academic honesty and ethical practice including individual freedom, social justice, honesty, responsibility and intellectual virtues,
- personal and public responsibility for professional decisions and actions.

Through this subject, students will be expected to:

- demonstrate the purposes and functions of mathematics in the community
- use basic statistics in reporting societal phenomena
- utilise a constructivist approach to mathematics learning
- use calculators and computers for investigating mathematics
- report their own discoveries and constructs within mathematical investigations
- create spreadsheets to solve mathematical problems create chars and graphs to illustrate mathematical relationships
- use the internet to explore and demonstrate mathematical concepts

Classes cover

- the nature of mathematics and information and communication technologies
- the calculator as a resource and the potential of ICTs
- data sense, creation of simple spreadsheets to explore numeracy
- data gathering for problem solving, graphs,
- problem solving, choosing and using numeracy, exploring mathematical ideas with spreadsheets
- nature of investigations, starting points
- patterns and connections, number sense
- patterns and connections, space sense
- internet evaluation of websites,
- developing teaching and learning resources. (Charles Sturt University, 2004, course coordinator Bob Dengate)

The 40 students (4 left for personal reasons) are on a small rural campus. About a third have entered from high school with the remainder entering as mature aged students with 2 to 25 years of post school experiences. On the other campus, the
students have one hour on technology such as Excel, calculators, and websites and two hours on mathematics. I was in a position to teach in the computer laboratory to integrate the numeracy and technology for blocks of three hours. Students also have a computer session per week to establish electronic professional portfolios using Dreamweaver and Build (for literacy). This computer experience also gave them extra experience with library databases, Word, Excel, Paint and Powerpoint.

The subject is accepted as an equivalent of two units of mathematics for the Higher School Certificate as this is a requirement of the NSW Department of Education. Students problem solve and investigate mathematics rather than learn how to teach primary school students to problem solve and investigate. Nevertheless, we begin by introducing them to the syllabus model that places Working Mathematically as the core by which students learn mathematical content. This Working Mathematically strand emphasises Posing Questions, Applying Strategies including using technology, Communicating, Verifying, and Reflecting.

The students have two assignments, one called a Community Project and one called an Investigation. The first requires them to decide on a project that required them to use mathematics to solve a problem related to the community. They were given a number of examples of appropriate topics.

The Subject Evaluation

The results of the project assignment illustrated that students could decide on appropriate questions to investigate. From a survey questionnaire that I gave them, only two felt that they needed more guidance with setting up this project question although this was not apparent in their reports. The chosen topics give an idea of how they perceive they could use mathematics in a community project.

- The progress of shares from selected companies and a survey of some business people on-line about their share buying and selling. This information gave the student a hobby and has allowed him to supplement his income as a student with a young family.
- The on-line uses and needs of small businesses in the rural city sent on-line. The local business development centre were keen to obtain this information.
- The reasons for nurses leaving the profession in the town.
- The energy used by her family’s use of electricity for lighting, cooling and appliances.
- The returns on following horses from specific thoroughbreds and ridden by specific jockeys.
- People's knowledge and attitudes about genetically modified foods.
- Attitudes to private and public schooling of parents with pre-school children in a rural town.
- Wheat sales, rainfalls and droughts over the last 10 years.
- Beef prices at different sale yards within the region
- Available loans for farmers;
- Purchasing appliances or shopping in a small town versus the rural city
• Availability of child care services in the country city versus a large coastal city.
• Attraction of local supermarkets and clubs.

All students achieved the collecting of data, analysis of data (not always using the computer if they were just obtaining frequencies of responses) and the graphing of results (about six students chose some inappropriate graphs while trying out the different kinds of graphs but in general they made excellent and diverse graphs). They prepared informative reports that included appropriate tables and graphs and a discussion of the results and the project methodology.

After the first half semester I asked them by an on-line evaluation questionnaire about specific lessons. In the first two classes, I used a powerpoint presentation to illustrate the variety of mathematics used by different people as reported in the newspapers. For some, these classes followed by their own use of mathematics in the community project gave students a whole new view on mathematics as being used to solve real world problems by many people.

I gave them an attitude survey with items requiring a response of strongly disagree, disagree, unsure, agree, strongly disagree. In groups, they entered their data into an Excel spreadsheet using 1 to 5 as code numbers for each responses to each question. They emailed this to me and I was able to collate the data quickly and place it on the subject forum for them to continue to work on. Already they were beginning to collaborate in small groups and as a class. They helped each other with attaching emails and reading the forum both skills we wanted them to achieve. After the practice of entering data, we (the students and I) used the Countif function to find out how many students responded 1 to 5 for the first question. This was the first experience with a function and for some it was too complicated so next time I will simplify the survey so the overall spreadsheet does not look so complicated. We then dragged across the sheet to find frequencies for responses to all items. We then drew a column graph of the responses to a few items using the chart wizard of Excel. We had to find out how to get appropriate labels and axes. This was later supported by their computer sessions. We also had a rank from 1 to 10 for overall feelings about mathematics. We used this to make a people graph, a picture graph (using post-its per person), and a computer column graph. We needed to discuss the frequency tables and graphs that they had made at school (some mature-aged students had not covered these at school) to try to make links with past experience and even the word frequency. We briefly discussed that we were using ranked but not interval data so other kinds of graphs were not really appropriate.

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We also took height and arm span measures and looked at averages, and standard deviations. This gave them further experience with both entering formula into cells, the Insert function and short-cut sigma icon. Dragging down the cells to give the range for the function requires fine-motor coordination that some needed to practise to overcome their anxiety and confusing results. When to copy and what happens when you copy needed exploring. If the arm span was less than 10 cm greater or smaller than the height, we labelled the person a square. Unfortunately, we ran out of time and in a later class we introduced the logical if statements. Similarly we had to leave the , and the correlation between height and arm span. Interestingly, when students gave surveys (some only collected data from 6 clubs or 15 to 20 people) for their community project and only about four students made use of this countif function, some collating by hand before entering frequency data to make a graph. I presume that it was a long time between this class and their final need to use it. The evaluation survey indicated that some could not see the value of collecting so much data and how it was relevant to teaching. This issue I hope to address next year by making greater links to school activities and by eliminating the project examples where a lot of data collection overshadowed the mathematical analysis.
I was surprised at the number who had reasonably positive attitudes to mathematics and themselves doing mathematics (Figure 1). Prior to this experience, a small number of students had Excel experience but it seems they had not considered its use as a mathematical teaching tool. There were about ten students who were quite anxious about the subject at the start but by the end of the second day, they were much relieved that they had handled both the Excel and the mathematics that we used in class.

We began the second lesson with the game of sticky numbers. Each student had a number stuck on their shoulder. They had to find out what number it was by asking others a question which had only a yes or no response (no more than 3 questions per student before moving on to ask another student). Occasionally, their fellow students answered incorrectly so I had to circulate to check. The range of numbers included negatives, irrationals, decimal fractions, fractions, and mixed numbers. Then the students stood in line from smallest to biggest number. We finished the lesson by groups organising numbers into subsets diagrammatically and discussing how the lesson idea could be made simpler for primary school students.

“It became fun. It was a challenge, playing with the numbers.” “The activity was good for taking the stress out of solving number problems and make it an enjoyable and social activity.” Interestingly, the activity gave some students a whole new view of numbers. “They come in a variety of ways and when using numbers I need to be very specific.” “That numbers are not only single digits, they are symbols, fractions, decimals etc.” “Groups could be made from the numbers other than what the class originally thought. Making a line from the smallest number to the largest number changed my feelings to view numbers in a variety of ways.” For example, the students found that fractions could be represented as a vulgar fraction, a terminating decimal and as a repeating decimal. These comments reflect a large number of students’ opinions. Nevertheless, some students still knew they “didn’t understand how they all came together.”

Figure 1. Graph from attitude survey Excel sheet.
However, despite the fact that the majority of students had fun with the sticky numbers, some of the anxious students still felt very embarrassed about their lack of knowledge. Through the next few weeks, I was quick for us to discuss in class responses from these students when they gave really interesting responses in finding patterns or described other investigative processes. They were quite pleased with their community project. We managed to turn around the anxious students into thinking they could do some mathematics, apply it and even succeed. “I think I’ve learnt a lot in this subject. I was very apprehensive about this because of my experiences with maths in high school, but it wasn’t so bad after all.” “I was very concerned that I would not be able to keep up with the class. But I find that (the lecturer) makes everything seem easier and I feel a lot more confident at attempting new things and I feel elated when I can understand what the lesson is about.”

I wondered whether the ITC would interfere or help the learning and finding of patterns. In particular, after their lack of the Countif function for the community project, I was keen to find out how they found Excel generally.

One of the activities was to find magic squares for which we used Excel. This lesson introduced them to finding sums and using other calculations. After trial and error and sharing of initial strategies (like placing larger numbers in the centre of the side rows or columns and putting 5 in the centre) for finding the magic square using 1 to 9, we looked at a few other strategies that might help to find more magic squares. Once they had an idea, then they really got into trying a range of ideas. Here the Excel program aided time. While a couple felt a little foolish at not doing it as quickly as the rest of the class, another student went home and played with it with her husband, having a real tussle with the mouse to see if they could out-compete each other. “Excitement was felt when number patterns in the magic squares were found, making other number patterns easier to work out.”

Prepare a Magic Square

Use formulae to make a new one

Try sequences

=Sum(B3:D3 etc

=B3*3 etc

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We used the drag feature after entering the first five numbers and we used colours to highlight number families helping students to see and discuss number patterns.
Make a hundreds chart

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Pascal's Triangle – highlighting the whole block beyond the edges and using Σ gave them instant row totals to look for patterns of 11
Students could list advantages of using Excel like:

Analysing numbers, finding trends, making sense of statistics, doing calculations easily.

It is a good tool to use for maths. Advantages include it works out the equations, help tool available, everything is visible after completed, things can be changed around. Disadvantages include could get confused and frustrated if you don’t know how to use the program.

Great tool. Time saving, accuracy, recalculating when changing a variable.

As a calculator … good for setting out work.

Advantages: Easy to enter mathematical data, easy to work out sums, by adding a function allowing answers to be automatically answered for you, allows for quick and easy mathematical solving of problems. Disadvantages: there is a chance of failure and technical error, confusion could arise if a function is applied to an area that it isn’t supposed to be.

I had a great deal of fun putting the project together. I enjoyed working on the charts and finding this new information out. Every time I go to the supermarket, my analysis is always in the back of my head.

Disadvantages were:

The complexity of functions and the possibility of using it in the wrong place and it takes a while to become familiar with everything.

Formulae knowledge needed, formatting skills needed.” “If you don’t know exactly how to do something there is a huge amount of fiddling and trail and error to get the desired results.

Their efolio and technology class also assisted with Excel.

We also explored a number of problems that encouraged students to find number patterns. These included the handshake problem and adding consecutive numbers
begun by using Cuisenaire rod staircases, mats), triangular and square and other shape numbers (begun by using counters). We listed results on the board as well as in Excel. Many students were invited during our number pattern lessons to come to the front and give their findings. “Problems that involve looking for patterns always interest me. I love looking for the pattern and get quite excited when I can find one that is complex.” They were happy to have a go with sharing any patterns that they could see. We also discussed Pascal’s triangle and put this into the computer (using every second square), adding all rows was informative, but students were able to find many different patterns so that some of the less confident felt they had found patterns. We followed this up with a websearch which challenged the better students to work out other patterns.

Many other types of problems were given to illustrate how they could use a variety of strategies to solve the problems. These were ones that Bob Dengate and I had collected over the years. We specifically discussed diagrams and patterns, working backwards, try and modify, asking questions, making it simpler and acting it out. Students were happy to share their incomplete ideas and to share their diversity of diagrams and so on. Many students would turn to the computer and start drawing and recording rather than work on paper. All these problems were given to pairs and the idea of working by themselves (each had their own computer) was soon gone. “I felt more at ease and started learning different strategies that I would never have thought before. It’s a way of looking at things from a different perspective.”

One question on my survey asked them what they thought problem solving was. A selection of responses follows.

Coming to a conclusion after having completed a number of different problems.

Looking for a way to solve a problem and come up with an answer, taking into consideration many different ways a problem can be looked at/thought about.

Looking at all the possibilities to a question and through trial and error coming up with a valid solution.

Working out a solution to a problem. Investigating the various solutions to a problem.

Problem solving is when you investigate ways to solve the number problem.

Analysis, deeper thought, broad thinking.

Working out how to approach a question in a fashion that sets you up to find an appropriate answer.

We should encourage students to look further into things and look for patterns and other interesting aspects.

Being able to be given a problem and research it to find answers to it. Investigation is looking at a question and analysing different aspects of it.

Finding a solution to a certain task, hopefully ending in a resolution.

Problem solving is to find out a strategy or strategies to solve a problem. It not only happens in mathematical problems but in real life. It is faced with us every day no matter how small or large. Investigation is a way of using thinking strategies to find a solution. The strategies must be noted how the answer was achieved.
Problem solving is when you face a problem with the need to overcome it in order to continue what you are doing. It is through the use of a variety of solutions to allow a conclusion to be found; therefore the problem would hopefully be solved. Investigation is looking into a situation or problem where a variety of answers could be obtained.

Getting information together sorting through it and investigating the information.

These responses are brief but indicate a reasonable view of problem solving.

At the time of the survey students were beginning to start their open-ended investigation (Bastow, Hughes, Kissane & Morlock, 1984). An example of these investigations is “A rectangle of squares is cracked along a diagonal. Investigate.” General comments at the end of the evaluation survey included four general negative opinions. “I am very confused and frustrated.” I am not sure if this referred to their open-ended investigation or their use of ICTs or both. The students presented their investigations to the class. Only two students really failed to go beyond the obvious starting point by the end of semester with this investigation. Most posed questions, explored other ideas, looked for patterns and several noted that they built on existing mathematical knowledge. Overall these results were very good.

The link between pedagogical knowledge and mathematical knowledge began to appear. This was particularly evident from the lesson on calculators where they explored the primary school type calculator for the first time, played games with the calculator, and viewed Groves & Cheeseman’s (1993) videotape. Many students comment on how they learnt about the calculator as a learning tool (see Groves & Stacey, 1998). One student concluded the survey by saying “I have enjoyed this subject and learnt a lot of new ways to teach maths. It has broadened my horizon and made me realise how teachers need to be open to new ideas and ways of teaching. Maths is less daunting for me as I see ways to involve the students in active investigations and problem solving.”

Other Ideas Used in the Subject

We used black hat elastic and drawing software to make different two-dimensional shapes. They were asked to draw as many different kinds of quadrilaterals as they could and we drew these on the board, adding to the collection and discussing them, giving them names and seeing how they fitted into subsets. This was an efficient way of revising considerable amounts of information about quadrilaterals.

After pairs of students gave Left and Forward commands to have their partner make a square and an equilateral triangle, we used Drape (a shareware program) to make procedures that were particularly useful for drawing polygons, exploring exterior angle sums and the links between angle size and number of sides. Tables for this were also constructed as a class on the board. This program, like Logo, introduces them to nested procedures, animations and variables. Several students used their animated pictures and their programs in their Power point presentations of their investigations at the end of the session.

Conclusion
This brief survey indicates that there is a need to use a range of teaching strategies for students to grasp new ideas. These included the interactive games even though students may have felt somewhat ill at ease. These games allowed students to share and to realise that sharing helped learning. Keys to learning were the sharing when problems challenged their mathematical approaches or knowledge, the fun, and the establishment of a culture of having a go. The use of concrete materials at various times also assisted students to make links between drawings, spreadsheets and reality. The technology assisted students to see and explore patterns. The technology provided alternative representations including formula summaries that enabled students to notice the patterns. For some, the technology organised their thoughts to see the patterns. For others, the technology was still something to negotiate while trying to find the mathematical idea. This was the second time I had approached this subject using technology. My skills at using it effectively have improved since last year. There are still aspects worth improving. Next year, I am hoping they will have their efolios set up so they can publish more of their investigation drawings and abstractions in order to consolidate their thinking.

References


