VIEWS OF MIDDLE SCHOOL GIRLS ON CALCULATOR USE IN MATHEMATICS CLASSES

By

WENDY YU

B.Ed., The University of British Columbia, 1995
B.Sc., The University of British Columbia, 1994

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

In

THE FACULTY OF GRADUATE STUDIES

Department of Curriculum Studies
Mathematics, Science and Technology Education

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

October 2002

© Wendy Wing-Tai Yu, 2002
In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia. I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of CURRICULUM STUDIES

The University of British Columbia
Vancouver, Canada

Date Oct 23, 2002
Abstract

This study examined middle school students' perceptions of calculator use in the classroom. Through autobiographies and group interviews, the students expressed what they thought about how calculators are used and how they should be used.

Calculators have been a topic of interest for many years now but with the advent of the modern computer, the calculator debate has been pushed to the sidelines. However, the question of how calculators should be used is constantly disputed. Some people believe calculators prevent the learning of the basics while others feel that calculators help students probe deeper into problems. This study addresses these concerns from the eyes of eighth grade students in middle school and attempts to answer the question: What do middle school students say about how calculators are used and should be used?

The findings were based on individual opinion and experiences of students within the study. In summary, the majority of students gave positive feedback towards the use of calculators within the math class. However, there were some concerns regarding basic skills (such as addition, subtraction, multiplication and division) that were voiced as well.

The students favoured calculator use as a tool in the math class as long as there was already a firm grasp of basic skills. Irrefutably, more time and a greater understanding of calculators by teachers will help students make the choice to use this tool effectively.
TABLE OF CONTENTS

Abstract ........................................................................................................... ii

Table of Contents ........................................................................................... iii

Chapter 1 – Introduction .................................................................................. 1
   Background Information ........................................................................... 1
   Rationale for this Study ......................................................................... 2
   Setting the Context ............................................................................... 3

Chapter 2 – Literature Review ....................................................................... 5
   Positive Attitudes regarding Calculator Use ....................................... 5
   Negative Attitudes regarding Calculator Use .................................... 8
   Students Views regarding Calculator Use ....................................... 11

Chapter 3 – Research Methodology ............................................................... 15
   The Interview Sessions ....................................................................... 17
   Data Collection .................................................................................. 19
   Analysis ............................................................................................. 21

Chapter 4 – Results ....................................................................................... 22
   Calculator Autobiographies ............................................................... 22
   Calculators vs. The Basics (Paper and Pencil Skills) ....................... 24
   Calculators Save Time and Help Organize .................................... 25
   Influences of Parents and Teachers ............................................... 28
   The Future of Calculators .............................................................. 30
   Summary ............................................................................................. 31
Chapter 1
Introduction

Once Upon a Time...

"Can we use our calculators?" I asked with hope. I could never understand when we could use them and when we couldn't. It never seemed to make sense to me.

"No calculators allowed." The response was expected, but nonetheless, disappointing. Of course, I wasn't one to just take 'no' for an answer.

"Why not?" I knew in my head her reply. "Because it would be cheating." I just didn't understand how it could be considered cheating when all I was doing was checking my work. Of course, the teacher won. I wasn't allowed to use it after all.

Many Years Later... As A Grade Eight Teacher

"Can we use our calculators, Ms. Yu?"

"Sure. But make sure you show your work. That's what you're being marked on." I let my students use calculators most of the time. I make it clear to them that it's important for them to show their work and it's the concepts that count. My attitude towards calculator use is that students can and should decide when it's appropriate for them to use it. However, from the many conversations I have had with colleagues since becoming a teacher six years ago, I realize that teachers hold many points of view about calculator usage. I wonder if the same is true for students. When is it appropriate to use a calculator? I wonder how my middle school students might answer such a question.

Background Information

The study of technology in education has been an area of interest of researchers and teachers for many years. There has been much research done with respect to the use of technology in the mathematics classroom (Kaput, 1992). Although we seem destined at times to equate technology with computers, the research in general focuses on calculators. Most calculators available to students today perform much more
than the basic functions, thereby making tasks that previously would have been extremely tedious with paper and pencil, more achievable in the classroom. As a result, it is argued that time saved from doing these monotonous calculations can be spent developing students' problem solving skills and improving their understanding of concepts (Kaput, 1992). In addition, calculators allow students to experiment and explore in ways that were impossible previously. For example, allowing students to use calculators in studying exponents, they can experiment with how exponents relate to multiplication (i.e., how $3^4 = 3 \times 3 \times 3 \times 3$). This versatility has prompted the National Council of Teachers of Mathematics (NCTM) (2000) to recommend that students at every grade level have calculators available for use.

Following such advice, I often give my middle school students the option of using a calculator. Some choose them, while others do not. I strongly believe in the versatility of the calculator as a tool for mathematics learning and my puzzlement with my students' choices around their use is what prompted me to explore the issue of calculator use further.

Rationale for this Study

A reason for conducting a study of students' views of calculator use stems from the fact that there has been much research conducted in the areas of teachers' and parents' views on calculator use, but less on students' views and opinions about calculators.

I have seen many students shy away from using calculators and have assumed that they did so because of influences from parents and teachers. Yet it is possible that
students' views on calculator use may differ from that of their parents or teachers. Consequently, it is important to investigate what students say about calculator use to ascertain first-hand when, how and why students might use calculators. In turn, knowing more about what the students say about their past, present and future use of calculators may guide educators in maximizing students’ use of this technological tool for exploring mathematics.

Setting the Context

My interest in studying students’ views of the calculator comes from the experience I have had teaching middle school. I found that my grade 8 students did not know how to use their calculators to their full potential or often used them unnecessarily. In teaching a unit about square roots and exponents, I discovered that very few students even knew what the square root button looked like. In addition, many did not understand the function of the button. Initially, I wanted to focus this study on how students use calculators. I planned to use the context of exponential growth as a place to explore how students use calculators to help them solve problems that are either routine or non-routine. Indeed, I followed through with one session where we focused on solving problems about exponential growth. In addition, I also preceded the exponential problem solving session with a problem session on patterns as planned, to see how the students would use their calculators. However, from the first interview session onwards, these girls shared their attitudes and feelings about calculators much more and discussions about how they actually used the calculators to solve the problems was limited. Consequently, although I carried out the sessions as planned, attitudes towards
calculators moved to the forefront as the study evolved. Thus the purpose of the research became “what are the views of middle school girls on calculator use in mathematics classes?”

Chapter 2 reviews recent literature in the area of attitudes towards calculators. As such, it points to the limited research available on students’ attitudes towards calculators. Chapter 3 describes the methods I used to document the voices of eight middle school girls as they talk about their past, present and future use of calculators. In Chapter 4, I share the findings garnered from student responses in the interview sessions. Finally, in Chapter 5, I conclude with a summary of the views of this group of students and offer ideas and suggestions for future practice and research.
Chapter 2

Literature Review

This review of related literature deals with calculator use in the mathematics classroom. I focus on recent research literature (1986 onwards) as it is after this point that research on calculators experience a resurgence. This review also includes articles and reports wherein teachers, parents and experts in the field provide their insights, including their suggestions for improving calculator use in the classroom.

Positive Attitudes regarding Calculator Use

Many researchers and teachers feel positively about calculator use and condone their use in the classroom. They base these positive attitudes on research and their own experiences in the classroom.

Teachers are an important influence on students. From her own experiences as a teacher, Burns (1994) has seen how helpful calculators can be. She believes that calculators should be available at all times like pencils, rulers and other tools for doing mathematics. She emphasizes the importance of having a well-balanced mathematics program in which the calculator is a tool that helps students become flexible in methods for dealing with numbers. She is a strong advocate of calculators at the elementary level. Because she believes so strongly in calculator use, she says she passes on this belief to her students and they choose to use calculators frequently in the classroom.

Another teacher that believes strongly in calculator use is Drosdeck (1995). Based on observations from her elementary classroom she believes that calculators are important and that they should be made readily available to all students. She suggests
keeping calculators on open shelves just like a teacher would store any other materials (such as base ten blocks). In her practice, she encourages children to use calculators in everyday situations at the elementary level (for example, buying toys from a catalogue). She also makes an important point about a calculator's role for problem solving. In using the calculator, it is important that students learn to decide for themselves when calculator use is appropriate. Rather than ask if they are permitted to use a calculator, students should begin to ask themselves if this particular problem would be better solved using a calculator.

Taylor and Thompson (1992) stress that calculators are important learning tools. Thompson works with the Family Math program headquartered at the University of California (Berkley). She collected and developed activities and watched attitudes change during her study. She also gives many workshops about Family Math. She believes that in the primary years, activities with the calculator must be developed that help students learn and think while convincing parents and administration of their value. She uses Family Math, which is based on the idea that family members can help to enrich mathematics learning by playing games and doing a variety of activities, to allow parents to see their children actively involved in constructive calculator activities. From her involvement with Family Math, she has seen parents' concern about the use of the calculator and watched their attitudes change as they see their children actively involved in constructive calculator activities. After conducting a survey, she found that many parents (and children) view using the calculator as cheating. The parents' beliefs are important since they influence the students. That is why parent education is so important. Parent night/family night, presentations, newsletters, invitations for classroom visits, and
homework involving parents are all ways to get parents involved and help them see the importance of calculator use (Taylor and Thompson, 1992). In summary, she has discussed the importance of surveying parents and educating parents about calculator use, both of which are very important.

Empirical research has also been done to show the positive effects of calculator use in the classroom. Much of the research shows that paper and pencil skills (also known as the basics) are maintained or even enhanced with calculator use. Dessart and Hembree (1986) summarized findings of 79 reports from kindergarten to grade 12. In their research, they examined the effects of calculator use on student achievement and attitudes in grades K-12 by interviews and tests. These reports show that using calculators allowed students to maintain their paper and pencil skills. They also found that higher achievement scores were obtained in exercises and problem solving when calculators were used.

I believe that calculator use must be important. I continued searching through the literature and found that at the middle school level calculator use is ideal for many reasons. First, the mathematics at middle school is diverse and presents many opportunities to explore. Second, this is the last time that mathematics is common before students enter secondary school and make program choices in mathematics. By making math more accessible by the use of calculators (students can now delve into problems of greater depth without doing tedious calculations), perhaps students would be encouraged to continue their studies in the area of mathematics. Third, students at middle school are at a formal reasoning stage and problem-solving experiences can aid in this development (Bright & Prokosch, 1995).
Schmidt (1998) surveyed thirty-two middle school teachers near The Ohio State University for their beliefs about calculators. She found that in general, teachers agree that calculators should be used in middle school, but teachers need help using them. Mostly, calculators are used to check answers. Teachers were also concerned about the amount of instructional time and saw calculator use as an add-on (as opposed to being an integral part of instruction). The teachers surveyed also thought that parental support was necessary in order for calculator use to be most beneficial. Overall, there was the belief that calculators can help develop concepts of number and number sense, there are no negative effects from their use, and students will not depend on them to a point where they become a crutch.

Negative Attitudes Regarding Calculator Use

Some teachers fear that calculators will take away from learning the basics. Sara (1999) is a retired math teacher and past-trustee in Vancouver who urges Parent Advisory Council (PAC) groups to lobby for the removal of calculators from the grade 1-10 mathematics curricula. She believes that the teaching of numeracy skills remains a serious problem in the province of B.C. She concludes that the allowance of calculator use and computer use has caused a loss in proficiency in mental calculation, especially during the impressionable years, which in turn has led to low scores in the provincial numeracy survey tests written by elementary students across B.C. She is one "expert" that feels that calculators should not be used. Although I agree with her point that learning the basics is important, I don't believe that if the calculator is not used students will be better able to memorize their times tables. Instead, calculators should be
introduced in accordance with learning other skills, such as the basics and teachers should guide their students on how to use them. (In addition, Sara’s reasoning is slightly flawed. In order for her argument to hold up she would need evidence of pervasive use of calculators by these students and she does not present that evidence.)

Although many students have access to calculators, many teachers are still not using them for various reasons. Colloby’s research (1998) hypothesized that there is a fear that calculators will undermine mathematics learning but she could not find evidence in her project to support such a position. She found that use is limited and one reason for that is due to personal prejudices of teachers. Calculators are primarily used to check answers and conjectures, but are seldom used to aid in the learning of math strategies. Another problem at the elementary (and middle school) level is that many teachers did not learn math with the use of calculators themselves and therefore have difficulty teaching with them.

Baldry (1988) is a grade 7 teacher at Laronde Elementary School in Surrey, B.C. His research indicates that the use of calculators in elementary classes has been inhibited for three major reasons. These reasons include fear of the calculator replacing paper and pencil skills, lack of calculator allowance on standardized examinations and an inability to use calculators effectively. His research involved the examination of various literature and his own experiences as a Grade 7 teacher in British Columbia. In his review of literature he found that educators fear calculators will replace pencil and paper skills. Baldry also pointed out that most testing (especially standardized testing) does not allow for calculator use. However, we do see how that is changing since there are now calculator components in standardized tests. Also, he found educators are unsure of how
to use calculators effectively. He elaborates that in order to use calculators effectively it is important that students are able to estimate and judge reasonableness of their answers. Baldry concludes his paper by suggesting that calculators be used as a tool for exploratory activities and for checking computations, doing complex computations and assisting in problem solving.

In speaking to my colleagues, I would agree that many educators feel that calculators take away from the basics. However, I am also seeing that many more teachers are starting to regard the calculator as a tool instead of a replacement of mental math. There are also many more resources to support calculator use that make educators feel more comfortable in teaching with a calculator today.

In a study conducted with principals from 80 elementary schools in rural Western Pennsylvania, Lehman (1994) provides suggestions to deal with the issue that there has been a long-standing resistance from teachers to use calculators in instruction compared to computer technology. In his study, principals completed a 22-item questionnaire designed to assess the nature and extent technology was used for the teaching of elementary mathematics and science within their buildings. Using multiple-choice and completion type questions, Lehman found that although calculator use is more frequent in intermediate grades, the frequency of its use is still lower than microcomputers. His suggestions to improve calculator use include a development of partnerships for staff development, targeting of all grade levels; availability of videotapes showing integration of technology; student teacher encouragement; and further case studies. I agree that much more education for teachers must be in place before they will comfortable using
calculators and also feel that further research, such as case studies, can indicate ways calculator use can be improved.

Reys and Smith (1994) believe that teachers need to better understand the role of the calculators in the classroom before they will begin using them. They discovered that teachers found it difficult to use calculators in the classroom partly because the textbooks were not written to accommodate them. Both teachers at the university level, they decided to examine mathematics textbooks from the early 80s to the early 90s. They found that in the early to mid 80s calculators were not relevant to curriculum. In the mid to late 80s, there was more calculator material, but it was still irrelevant to the topic of study. It wasn’t until the late 80s and early 90s that calculators in textbooks were included with relation to the curriculum. Therefore, it wasn’t until recently that teachers began teaching calculator use in relation to the curriculum. However, it will still take more time before calculators will be used regularly as a tool in the classroom. They also believe that calculators are no longer merely a means to check computations, but serve many other purposes.

Just from these examples, it is clear there are both positive and negative attitudes towards how calculators are used in the classroom or if they should be used at all.

Students Views regarding Calculator Use

Despite the debate over classroom use, the importance of calculator use is overall supported. Saunders (1998) surveyed 100 occupations, and of these occupations, 98% involve some calculator use. In addition, some standardized tests have calculator components (e.g., SAT, PSAT, AP Calculus). There is speculation that these
standardized tests and calculator use may filter to lower grades and therefore students may find it necessary to use calculators for standardized tests as early as in the primary grades. In addition, Usnick (1995) states that calculators are important tools to help enhance learning, teaching, and assessment.

To support this, the NCTM states that all in-service and pre-service teachers should be better educated in calculator use (Ayers, 1991). Usnick (1995) describes a module developed at Texas A&M University that would help teachers learn about calculators, mathematics and the incorporation of calculators into their teaching of mathematics. The results of this developmental project showed that teachers learned flexibility in dealing with the power of calculators by approaching the use of technology with an open mind. NCTM also states that the use of calculators should be promoted to encourage students to focus more on problem solving skills.

The reader is reminded that earlier in this chapter it was shared that Dessart and Hembree (1986) found that students who were allowed to use calculators received higher achievement scores in exercises and problem solving questions. In addition to that, and probably even more relevant, is that students who used calculators had better self-concepts and attitudes towards math.

Similarly Reys and Reys (1987) conducted a study by comparing primary and intermediate elementary students who used and did not use calculators and found that those students who chose to use calculators exhibited more confidence and persistence in problem solving.

With all of this, it is still evident that very little work has been done to find out the views of students with regard to calculator use. Ruthven (1995) used a questionnaire to
survey over 300 students who had just entered their first year of secondary education in the Cambridge/London area. These students ranged in age from 11-16. In his analysis he found that students’ attitudes about calculator use depended on the degree of enjoyment of number work, of confidence in alternative modes of calculation and their degree of skepticism about the legitimacy of the calculator.

My intention was to select a small group of students and get more depth in their answers about their beliefs about calculator use at the middle school level.

From the examination of the literature, there definitely exists reason to find out more about calculator use, especially with regard to students’ opinions. There is evidence that teachers consider calculators as important but are not using calculators for a variety of reasons, especially at the middle school level.

Studies explore how teachers feel and why they feel this way, what administrators think can be done about calculator use, how parents view calculator use. However, few studies examine what students’ beliefs are. Why do students prefer to use calculators? How have their parents’ views affected their childrens’ views? I began to wonder if students also debated about calculator use and if teachers, parents and researchers have influenced their thinking at all. There has been very little research done in this area of students’ views and attitudes. By finding out what students think about calculator use, we can then look at our own practices and speculate as to why students aren’t using their calculators to their full potential. Only then can we adapt our teachings to suit the constant changing needs of the technology users of tomorrow.

I believe that calculator use is essential in today’s world and every person must learn to make good use of the resources that exist. By discovering students’ attitudes
toward calculator use, I will hopefully be able to determine how to change my own practices to better include and support calculator use during my instruction.
Chapter 3

Research Methodology

In order to proceed with answering the question of how students use calculators in the classroom, I chose to confidentially interview eight students who are registered in an eighth grade math class in a school located in a suburb of Vancouver, Canada. The interviews contained spoken and written responses, both of which are included in the results. I chose to do interviews in order to probe further (i.e., ask follow up questions) into the issues as they presented themselves. I chose a group format rather than individual interviews for several reasons. By working as a group, students said they were more comfortable and better able to articulate themselves, add to each other’s comments and build on each other’s ideas. Interviews in group format provided the most convenient for everybody’s schedule. These students were very comfortable with each other and were able to speak freely and share their opinions without feeling judged by one another or by myself. In addition, they were already strong, confident students who were not afraid to speak their minds and the group format better approximated a ‘classroom’ setting which for me was important since I wanted to find out about views in mathematics classes.

The four group interviews took place from April 2000 through June 2000. Every student registered in Math 8 was given the opportunity to participate. An initial letter went home to the parents and all interested parties responded. When I initiated this study, I chose to approach students in my class because I had taught them for the first half of the school year and conducted the study in the latter half. Although I wanted an
equal number of females and males, only females responded to the permission letter. It was difficult to get more students in this age group, especially boys, to volunteer for this study therefore the core group consisted of eight female students. Also, ideally I would have liked to have a variety of ability levels represented, but the students who volunteered to be interviewed were all high ability students and all achieved a very good to excellent standing in previous mathematics courses. Everyone who responded and was interested was involved in the research. From talking to the students during the interviews I discovered that each of the students involved in the study had limited experience with the use of calculators in previous grades and used calculators infrequently presently. The identities of each student will remain anonymous, as pseudonyms have been used. The students in this study are from middle to upper-middle class homes and included students from a variety of cultural backgrounds including those that were Canadian (for many generations), Chinese-Canadian and Korean.

The study took place at my residence since I was no longer working at a school. However, the parents already knew me (since I was a teacher at the school for a few years already and had been teaching this group of students for half the year) and trusted the students to come by themselves. Students were required to bring pencil and paper and a calculator to each interview session. I wanted them to use their own calculators since they would be familiar with them and know how to use them well.

Although I was no longer the teacher of these students, I made them aware ahead of time that their participation in this study would in no way affect their academic standing in math class.
The Interview Sessions

There were a total of four interview sessions, each being about 30 to 45 minutes in length as the students were all very good students and were extremely focused. Every interview was videotaped. Due to everyone's schedule, the interviews were anywhere from a few days apart to a week and a half apart. The first session was a preliminary interview. The purpose of this interview was to get to know the students better and find out about their calculator use in their past. Each student wrote a "calculator autobiography", where they described their experience using a calculator from the first moment they remembered until now (see Appendix A). I told them to include when they remembered using a calculator, who promoted and who disapproved of calculator use, what their parents thoughts were (if they knew) and anything else that had to do with calculator use. I left this fairly open ended and allowed them to write as much or as little as they wanted. By "autobiography", I merely hoped to get a personal look into their mathematics lives as told by each student. Most students wrote a one paragraph autobiography. I also took this time to tell them about what I was researching and help them feel at ease by ensuring them that they will not be judged. They were simply to answer as freely and naturally as possible. In the second part of this session, I began asking them questions that dealt with their thoughts with regard to calculator use (see Appendix B). Each question was posed to the whole group and whoever wanted to go first began stating her response.

In the second interview, we looked at the calculator more closely and I found out how well students knew their calculators. For example, I asked students what the various keys are and how they are used. (Some students had never used the 'memory key' on
their calculator before). I also continued to ask questions dealing with their thoughts about calculator use (see Appendix B). For homework, students were asked to go home and ask their parents for their views on calculator use.

The third interview required students to attempt various questions involving calculators (see Appendix C). Most of these questions focused on problem solving and reasoning. The students were allowed to use their calculators for these problems and then after answering the questions, I asked them how this session would have been different if calculators were not allowed. The second half of this interview required students to share their parents’ views on calculator use.

The last session involved asking students some problems that were concerned with exponential reasoning, which was the initial purpose of my research. In the second half of this session, students worked together to explain to me how they would help other students make better use of their calculators by proposing an activity or game they could teach them.

Again, the reader is reminded that each interview session was carried out as planned when the focus was to be on how students use calculators. However, as these sessions unfolded and as I began to analyze the data after the sessions were completed, the focus shifted towards the recurring theme of these girls’ attitudes towards the use of calculators. As the study progressed and I discovered that the students were voluntarily speaking about their attitudes more, I also discovered a limitation in the videotaping procedure. That is, part of the difficulty in ascertaining the girls’ use of the calculator to solve problems lies with the set up of the video camera. In order to best capture what students do on their calculators, a camera would need to view over the shoulder of each
student onto her calculator. In the group setting such video taping was not done nor is it perceived feasible. Thus, as I debated during my analysis stage whether to focus on attitudes or problem solving, I chose to examine the more accessible data that was available on the girls’ views.

In addition, the length of each session may also be questioned by the reader. Each session lasted 30-45 minutes because the students remained focused on the assigned tasks or questions and completed each efficiently. In looking back, many of the questions asked could have been developed further if I had probed deeper into the girls’ thinking and asked follow-up questions. However, as each session unfolded I found myself not wanting to break the flow of the session, by interrupting their train of thought, and as a consequence I did not offer follow-up activities but permitted them to steer the conversations. For example, when noticing a student’s actions on the calculator I realize now that I could have asked ‘can you explain why you did that?’ instead of moving on to the next problem. To do this in the group setting would resemble reviewing individual’s solutions in front of the group or at their side and since the individuals did not request such action, I maintained an observational role. Perhaps a one-to-one follow-up interview would have provided a more suitable setting for such probing.

Data Collection

Each session was videotaped and to help analyze the information, notes were taken during and after each session and upon reviewing the videotape. The videotape served mainly as a device to capture audio, but also provided some hints of the whole group and how they interacted with each other. However, I only used it for audio
purposes. Also, I asked students to document on paper any calculations that they did. Along with all this, I asked the students to write an autobiography of their calculator life. This documented how they used calculators in the past and how they felt about that use (Appendix A). By linking autobiographical information with their present views, I was able to see how their past experiences may have influenced their present views.

My role in the conversation was as a facilitator. I asked the questions and allowed each person to have their turn answering. I also made sure that each person had an opportunity to comment if they so desired. Using group interviews was a great time saver for me and it was the best way for me to get a lot of information in a short amount of time. I think I would have ideally liked to interview each student separately so that students wouldn't have directly influenced each other as much. (However, if I had done that I would not have gotten the 'build-up' of comments that students had. Sometimes a comment made by one student triggered something else in another student).

Prior to the interviews, I designed questions based on what I wanted to find out. For example, I tried to ask open-ended questions that were non-leading. This worked quite well because the students were willing to respond with no prompting from me. (As I said, they are strong, confident girls who share their opinions openly). I did not want the students to be influenced by what I thought and so I tried to remain impartial at all times. The questions were posed to the group as a whole and whoever wanted to answer could answer them. From there, any other student that wanted to add her opinion or build on previous ones spoke in turn. I gave students as much time as they wanted to answer a question. When they finished, they would let me know or just stop. If they had something to add they would raise their hand and add their comment later. I also
clarified with them that if they did not have a response they did not have to respond to a particular question. When asked if there were any questions, the students did not have any before, after or during our sessions.

Analysis

I viewed the tape once, and reviewed parts that were of particular interest to me. To help with the writing process, I transcribed all of the sessions and pulled out highlights. After the tapes were transcribed, I began sorting through the transcripts, looking for any common themes among the students. I was hoping to find that these students (who were quite similar academically) shared similar beliefs about calculator use. I expected that because these students were not low academically, they would not depend on calculators for every day use. I thought they probably would be able to take it or leave it. I was looking for how they used calculators in the classroom and out of the classroom. I narrowed the themes to those that seemed most prevalent to me. I decided on prevalence by choosing themes that seemed to reappear over and over or that were talked about at length. Any items that were mentioned a few times by different students or items that were cause of lengthy discussion were of greatest interest to me --- In addition, I examined the similarities or differences that resided in their explanations and reasoning as individuals.
Chapter 4

Results

In this chapter, the main themes from this study are presented and discussed. All students attended four group interview sessions and answered a variety of questions (see Appendix B), solved different problems using a calculator (see Appendix C and Appendix D), and discussed their thoughts and feelings on calculator use. Responses are summarized, along with supporting data from these sessions. All voices have been represented in the interviews, although not every student chose to answer every question. Most of the responses have been taken from sessions one and two since the analysis focuses on students’ beliefs about calculator use.

In my initial plan, I wanted to see how students used calculators to solve problems so I included problems in sessions three and four. However, I decided to take those problems and instead of looking at their answers, I decided to see how they actually solve them using their calculators and if they used their calculators the way they said they would, as a form of “triangulation”.

Calculator Autobiographies

The first data source that was of great interest to me was the students’ ‘calculator autobiographies’ (see Appendix A). The students did not begin using calculators until their intermediate years (about grade 5 or 6). Their autobiographies share the opinion that the calculator can be helpful at times, but isn’t really so important to them.
It is interesting that Catherine, who came from Korea and has been living in Vancouver for about two years, never used a calculator, even for play or experimentally, until she arrived in Canada. The rest of the students were born in Canada and most of them have used calculators to some degree, if only for play (for example, to write words on it like 'hello'). It was interesting to see the cultural differences on calculator use and this may be an area of interest for another time. Anna, however, is a little bit different from the other girls, as she has been using a calculator since she was little. She had exposure to a calculator since kindergarten because she has older sisters who used them. She still stresses that her parents did not let her use one until she had an understanding of the basics.

They started using calculators later in their schooling and they believed that others should not use calculators until later as well. The first question asked of them during the interview session was, "What are your feelings/beliefs regarding calculator use and why?"

Buffy: I think you should start using calculators in grade 5 or 6 because that's when you get into problems and big equations.

Sapphire: I think that people should be introduced to calculators in high school. Up to grade 8 you can still do it [work] without needing a calculator.

Stephanie: You should start using calculators in grade 9 and up because you're getting to more complicated problems.

Anna: I don't think there should really be an age where you start using calculators. It should be when you know how to do everything by hand, like addition and subtraction and multiplication and division.
Although all the girls who answered this question believe that calculator use is important, they do not necessarily agree on when it should start. In answering the question, Buffy, Sapphire and Stephanie all thought that a later introduction to calculator use would be appropriate because until the intermediate/high school level, calculations are still easily done by hand. However, just because they would start using the calculator more regularly for more sophisticated problems later, they did not mean that students should not have some exposure to calculators before that; for example, to play games or check work as the students expressed in their autobiographies.

Anna is the one student who did not put an age/grade on the introduction of calculators. She believes that before calculators should be used, students should have a good understanding of the basics.

Calculators vs. The Basics (Paper and Pencil Skills)

The students involved in this study valued the learning and maintaining of the basics. They believed that learning paper and pencil skills were very important and calculator use should take place only after these skills are in place.

Buffy: Basically I really like my calculator ‘cause it’s useful... but what I think is that it’s better to rely on your brain than your calculator because you have your brain and if you rely on calculators too much and then when you’re older and you’re outside and doing stuff you can’t really use your brain.

Sapphire: I think calculators are good but I think before you use the calculator you should learn how to do the work yourself, because if you don’t ...If you just use a calculator and you don’t know why numbers come up then you’re learning how to press buttons and not learning how to do the stuff. So you should learn how to do the equation first and know why certain numbers come up before you use a calculator.
Catherine: I don’t think it’s a good idea using the calculator. First of all, when they’re using calculators, they don’t use their minds and (learn) how to do equations. When I first came to Canada, I didn’t use a calculator because my parents didn’t let me use it. And when I use calculator it was slower than using my mind.

Leanne: Calculators are also a handy tool when you’re doing your work and you’re not sure if it’s right. So when you’re done your work you can go back to your calculator and put the question in the button and see if it’s right.

Sapphire: I think calculators sometimes are bad because you think you typed in the right thing but then when you look at the answer, you think that’s the right answer. And then you try doing it yourself you get different answers. You may be doing it right yourself, but you get a different answer from the calculator because the calculator could make a mistake if you typed in the wrong thing. So calculators can make mistakes and you can’t always rely on them.

Overall, the students agree that calculators can be useful, but it is more important to rely on your brain first and know the basics. In another session, I watched them do problems that involved the option of using a calculator or not. Every student decided to use the calculator to aid in the process of solving the problem. (Appendix C) None of them tackled the problem first and then checked their answer with a calculator. Sapphire didn’t do her work first as she suggested she would do in the interview. Also, Catherine, who said that calculators were not a good idea, still used the calculator as much as the other students to solve the problems. (However, the reader is reminded that all of the girls are excellent math students and already knew their ‘basics’ before using the calculator.)

Calculators Save Time and Help Organize

Repeatedly, the girls talked about using calculators to speed things up.

Buffy: On tests, if you’re allowed to use calculators it saves
a whole lot of time... In middle and secondary school it would save a whole lot of time.

Sapphire: It’s good for multiplying big numbers because that just takes time and you know how to do it, it just wastes time.

Leanne: ...then you should have a calculator because it saves a lot of time...(when you) know how to do the problem it helps you get it done faster.

Stephanie: I think calculators should be used for checking over work unless you want to save time or something.

Anna: (It’s good for)...if you’re in a hurry.

Throughout the interviews, the concept of saving time came up in many answers. The girls believe that once you know a concept (such as multiplying multiple digits) you shouldn’t have to waste time doing those tedious tasks, but rather you should be given the calculator as a tool to aid in performing these tasks.

In addition to saving time, the girls felt that calculators helped them organize when problems had many steps:

Tania: When I use a calculator, I use it mostly for percents and discounts to figure out how much things cost. That helps me a lot to figure out what I need to do.

Catherine: When I’m doing multiple questions or like BEDMAS. Mine has a bracket so I can do times first thing and then add and subtract later.

Leanne: Square roots and averaging. Averaging is pretty good because you can add up all the numbers and then square roots are good because sometimes they’re pretty hard to find and you can just press one button and you can get the answer.

Sapphire: I like to use calculators for cosine, sine and tangent. It’s a lot easier than writing it out and you can’t really solve for things like that. Also, when you have a right triangle and
you need to find a different thing it’s easier to use a calculator
than try to figure it out yourself. That’s what I use a calculator for.

By using a calculator, they feel they are able to sort out their work by breaking
larger problems into smaller, more manageable chunks. For example, Catherine talks
about working with BEDMAS. Using a calculator, she can organize what needs to be
done first, record those answers and continue with the other operations without getting
confused.

Many researchers have discussed the importance of calculators as learning tools
(Thompson, 1992), but little research has shown that students use calculators for the very
practical purpose of making their lives easier! As mentioned earlier in Chapter 2, Dessart
and Hembree (1986) showed that students who use calculators have better self-esteem
and confidence in mathematics, but nobody has mentioned the practical uses of
calculators in their research. Drosdeck (1995) makes an important point about
calculators by stating that students become more comfortable and more confident with
calculator use when they can decide for themselves when it is appropriate to use
calculators. These students use the calculator to help save time, check answers and
organize their work. In fact, when watching the students perform the problem-based
tasks, they all used a calculator in some degree. In my observations I noted that Buffy
used the calculator as a guess-and-check tool. She would think about the question and
then fiddle around with the calculator, jot a few things down and try again. Others, like
Leanne, used the calculator constantly, but also more cautiously. She would think about
something, write a few ideas down and then enter items into her calculator. Regardless,
all of the girls decided to use calculators during the problem solving sessions and some, like Tania, even saved information in the memory of the calculator to be recalled later.

Influences of Parents and Teachers

Two of the most influential people in a student’s life are parents and teachers. Some teachers are complete advocates of calculators (Burns, 1994), but others fear that calculators will undermine mathematics learning (Colloby, 1988) and some believe that calculator use causes a loss in proficiency in mental calculation (Sara, 1999).

The students in this study were asked to go home and collect their parents’ opinions on calculator use. Toward the end of session three, they shared their parents’ thoughts about calculator use in the classroom and for homework. In addition, some of them spontaneously shared their teachers’ views on calculator use.

Leanne: My mom thinks that calculators are good for figuring out problems that take a lot of time but you should still know how to do the problem before you use a calculator.

Sapphire: I talked to my dad about calculators and he says that elementary kids should not use calculators and middle school kids maybe and high school kids should. He says he likes calculators and he uses them a lot for money things and doing his job and he’s a mechanical engineer.

Stephanie: My mom didn’t have a chance to use them when she was a kid because they weren’t really around. But now she uses them for everything - balancing her checkbook and budgeting.

Anna: My mom thinks that calculators are good helpful tools. They could be bad if you get dependent on them without knowing how to do it by hand. Kids need to know the basics first; the basics such as addition, subtraction, multiplication and division.

Tania: My dad thinks calculators are handy and useful and helps save
time. He doesn’t think kids should forget how to do math by themselves on paper. My mom believes that calculators can be helpful and fast when it comes to do complicated calculations quickly. They should be used to check work. Students should know how to do procedures first and should not rely on them until they know how.

Buffy: My parents think you should use calculators when you deal with complicated numbers and money. It could save some time. My parents used calculators in high school.

Anthea: My aunt thinks that using calculators is okay, but depending on age level and ability of math problems that everyone should know how to do all the problems without using a calculator because as kids they never had calculators. It saves a lot of time but it doesn’t really do you any good if you don’t know the formulas and how to actually work out the problems. So depending on the ages she thinks that it’s okay to use calculators.

Sapphire: This year in Math I had Mr. D and he introduced us to sine and cosine and tangent. He let us use the calculator to know how to do them, but in the final exam we didn’t use them. He thought they were okay but he didn’t think we really needed them and didn’t want us to depend on them.

Tania: My grade 5 teacher didn’t like us using calculators because she wanted us to figure out the equations first so she didn’t really like us using calculators when we did our math.

Leanne: Ms V let us use it for certain units but not for others. On the final exam we weren’t allowed to use it. They made it so we didn’t need it. I thought it was better ‘cause everyone did it for themselves and we didn’t have to rely on our calculators.

It is interesting to notice that many of the students and parents share similar beliefs. Perhaps the parents have influenced these girls and their way of thinking about calculators. Sapphire, Tania and Leanne commented on three separate teachers that they had for math. All of these teachers did not allow or allowed in limited fashion the use of calculators. This also reinforces the students’ opinions about calculator use. If they got the message from many teachers that they didn’t need to or weren’t allowed to use
calculators, then it seems that they would be less dependent on them (since they couldn't use them anyways).

The Future of Calculators

Students were asked to think about calculators in the future and share their views about whether or not they think calculators will become obsolete, why or why not, and if so, what will replace them. They were given as much time as they needed to answer the question (within the session) and whoever was ready answered first. They were also asked how they saw themselves using calculators in the future and who benefited from using them.

Stephanie: I don’t really think they’re going to go obsolete or disappear because people rely on them too much.

Leanne: Calculators won’t become obsolete. I don’t think calculators are going to go away because we need them.

Sapphire: Regular calculators might be obsolete but when technology advances everyone will have those Palm Pilots or the Internet and writing systems and math things. Some people feel that they have to have a graphing calculator.

Buffy: Because science and technology are improving and always will, I think in the future you don’t have to use a calculator as much but I don’t think its going to go away.

Tania: I think we’ll always need them because we rely on them and use them every day.

Sapphire: I think some of the jobs [that would require calculator use] would be an engineer or scientists who have to figure out ratios and different ways of building things.

Leanne: Everybody benefits from it because everybody has to do income taxes and you have to use a calculator to do income taxes.

Stephanie: People like teachers and bankers [use calculators in their
jobs] I guess because they have to figure things out pretty quickly.

Most of the students agree that calculators will not become obsolete. Some of the students believe that they will become more advanced, but there will always be a use for them. As Usnick (1995) indicates today’s calculator is much less powerful than the ones that will be used in the future. Therefore students should learn how to use them.

In addition to stating professions that benefit from calculator use Catherine, Buffy, Leanne and Anna also thought that students in high school and college greatly benefited from calculator use. As Saunders (1998) points out, 98 of the 100 professions he surveyed involved calculator use. These girls thought many people would benefit from calculator use. It is encouraging to see that these students see the calculator as a real-life tool and that it is useful in society, is used in many careers and will probably be useful to them in the future.

Summary

Although the girls in this study started using calculators later (in their elementary intermediate years), they all use them to some degree in solving problems. However, they do believe that the basics should be learned before students should start using calculators. Most of the students discussed how calculators helped them save time in the calculations. Once the basics were learned and understood, there is no reason why students cannot use calculators as a practical tool to assist them in their calculations.

The students in this study also echo their parents’ views and some teachers’ views as well. This finding seems to point to a relationship between what an influential adult thinks and how these students feel about calculator use for mathematics.
The future of calculators to these students is definite. They believe that there will always be a place for calculators (since they are becoming more and more powerful tools with every generation). They also see the importance of calculator use in the real world and may use them in their future jobs or careers as they were able to think of many situations out of the classroom and professions where calculators would be used.
Chapter 5

Conclusion

The purpose of this study was to discover what students at the middle school level think about calculator use. Before the study was conducted I wasn’t sure when or why students felt it was appropriate (or inappropriate) to use a calculator. The specific research question has been: “What are the views of middle school girls on calculator use in mathematics classes?”

This discussion will focus on the results presented in the previous chapter and whenever possible, link the findings to the literature which has also been shared in an earlier chapter. I will also share what I learned along with some implications for teachers and for teacher education in the future.

A Useful Tool

When interviewed all of these students stressed that they had learned their basic facts well and did not depend on the calculator. However, when faced with problems and having the calculator in front of them, not one of them passed up the opportunity to use this tool. The girls in this study treated the calculator as a tool. It was helpful in making them more efficient and simplifying matters, but did not do the work for them. The students seemed to understand why they were doing certain things on the calculators; they were not just randomly pushing buttons. They shared that they still mainly use calculators to check their answers.
The students in this study were responsible users of calculators. They understand that the calculator is just a tool and a tool is only as powerful as the person behind it. For example, they were able to explain all of their work and demonstrated that they understood the concepts. The calculator was merely there to help them do the ‘tedious’ math. Their choice to use the calculator is made because they already know how to do the work.

I learned that even though the calculator is there, many students (in this case, most of them) say that they do not necessarily need to use it. However, I observed that if a calculator is there and students are allowed to use it, more often than not they will pick it up and use it.

As the old saying goes, “...the apple doesn’t fall far from the tree...” Many of the opinions shared by the students were mirrored in the opinions of the parents.

Before conducting this study, I expected to see that the students’ opinions and the parents’ opinions would be similar and indeed they were therefore I was not surprised by their comments.

Future Research

The research done on opinions of middle school students about calculators has been limited in Canada. As Bright & Prokosch (1995) found, middle school is the ideal time for students to be using their calculators. In order to help students become effective users of calculators, it is important that we gain an understanding of what they already know about calculator use and how they feel about using calculators. The results of this study suggest that further research needs to be carried out in this area in other Canadian
schools as well as schools in the United States and it would be especially interesting to see this research paralleled in areas around the world (e.g. Asia). This research may help debunk the myth that calculators are ruining young minds and that young people are not learning the basics.

It would be useful to follow these students into their high school years and see how many of them choose to continue their studies in the area of mathematics and to see how their views on calculators change over the years. It would also be useful to do similar research looking at other groups and other samples. In addition, it also would be interesting to interview some parents who strongly believe for or against calculator use and interview their children to see if their opinions paralleled. Another study conducted with parents to see what they said they would do with regards to the calculator (use it or not) and then observe what they actually did would also be of interest. (Is it human nature to use a tool that is offered to you just because you can?)

In follow-up studies it would be useful if the researcher decided to use individual interviews as well as group sessions. Although one-on-one may be intimidating for a few students, this would be the best way to probe further into the issues brought up during the group sessions. This would be particularly informative if statements or actions which arose during the group experiences were probed more fully on an individual basis.

Future Practice

From the results of this study, I believe that I will somewhat change my own practice. Although the results of this study are not really surprising, I have come to see the importance of calculators as a tool even more so than before. I usually let my
students choose whether or not they want to use a calculator. I believe it is important to learn the basics, but calculator use is one of the basics. In the past, I have spent little time teaching about calculator use; it seems that it is difficult enough trying to get through the curriculum in the allotted time. I am not saying that I am going to teach a unit about calculator use separately, due to the fact that I don't have the time and it would not be relevant to the students if it was separated out of daily math activities. Therefore, I am beginning to integrate calculator lessons into my daily lessons. Usually after a concept is grasped (assessed by quizzes or other evaluative measures), I will show the students how to do it on their calculators. Something I would like to do is include the parents more in their children's learning because I feel that if I value calculator use without the support of the parents, then I will ultimately lose, and the students will not learn to use the calculator as a tool.

In addition, I have come to see that many fellow teachers are still shying away from calculator use. My goal is promote calculator use among my colleagues and share why it is so important. I would like them to regard the calculator as a tool at all levels. For the teachers of students in younger grades, it is important that they use the calculator as an exploratory tool and as the students get older more advanced calculators come into play. I am recently finding a greater interest in graphing calculators and am making it a personal goal to learn more about them and how to use them more proficiently. The best way to get other teachers to buy into the technology is for me to get very comfortable with it first.

The students in this study acknowledged the advantages of calculator use. However, this study points out that although it is not always necessary to use a calculator
for some problems, it is handy and almost comforting to have one on hand. However, the
calculator is a tool. The students in this study could have done the problems without the
use of a calculator, but they all used it in some way (either to check their work or to aid
in addition, subtraction, etc.). They are becoming empowered by making this decision
for themselves and in doing so, they are hopefully gaining the confidence and skills to
solve problems more efficiently. In understanding that, we as educators must make sure
we are not only comfortable with calculators ourselves, but to make sure that we help
students learn the importance of calculators as a tool and teach them how to use it most
appropriately.
References


Appendix A:

Students' Calculator Autobiographies
Catherine

When I was an elementary student, the teacher never let us use a calculator, because when thought that using a calculator was totally crazy to students. You know that I lived in Korea until I was in grade 6. I had no idea how to use the calculator or how it looked like. When I moved to Vancouver and became a grade 8 student, my teacher started to use the calculator. The first time I used the calculator it was way slower than doing it with my head, but now it’s way easier to deal with calculators. I don’t think that using the calculator is a good idea.

Stephanie

When I was young I never had a calculator, not for any particular reason. Last year, I got one yet I still do not use it all that much. I think that it was a good idea that I never had one because I learned a lot more about how to add and subtract numbers as well as do fractions and other various things. I think if I had used it then I would not know as much about all those things. If I had one when I was younger I think I either may have used it too much or not really used it at all.

Leanne

I started frequently using a calculator in grade 5, for math. I just use my calculator for math work. In grade 5, we were usually allowed to use them as long as we wrote down the work that we did on our calculator. I don’t really use calculators for anything but math. For multiplication that you already know how to do, a calculator saves a lot of time.
Sapphire

When I was in elementary school calculators were used very little and I don’t really remember how we used them. I didn’t really use it like I needed to use it until grade 9 going into sine, cosine and tangent. When I did this unit I used it all the time. Other than that, in grade 9, I sometimes used it to do my homework with boring things that waste time like adding or multiplying big numbers. I think that it’s good that I wasn’t introduced to calculators at a really young age because then I know why what numbers come out of it instead of not knowing why.

Anna

I’ve been exposed to calculator ever since kindergarten because of my older sisters. Since my parents didn’t want me to learn how to properly use them until I could do all the simple addition, subtraction, multiplication and division by myself. I just played around on them. We weren’t allowed to use them in school, unless on calculator units, until probably grade 6 when they were sure that we knew how to do it by ourselves. This year we don’t use the calculators that much in class work, but it’s good to know how to do everything by hand, yet still have a shortcut to speed up the process.

Tania

When I was young I didn’t use the calculator for my math. As I got older I started to learn about the calculator and how to use it. My mom encouraged me not to use it and to do the math in my head. I did that until about grade 5. In grade six, the math was getting harder so I decided to start using it. Now that I am in grade 8 I use it to
help me with my math, not very much though. I think that the calculator can help us learn about the problems and how to solve them.

Buffy

Calculators, for me, were never in use until roughly grade 5 or 6. When I was younger, my parents told me that it is best using your brain than relying it on a calculator. When I was in grade 6, we were allowed to use calculators just as long as we show our work in math. I think calculators are very useful as long as we use it wisely. In grade 7, we were allowed to use calculators on some tests; it was actually very useful and saves a lot of time. This year, you were kind of allowed to use calculators, but not on tests. I like using calculators because it’s quite fun pressing those little buttons. I also like making words on the calculator such as ‘hi’ and ‘hello’.
Appendix B:

Questions from Sessions 1 and 2
1. What are your feelings/beliefs regarding calculator use? Why?

2. What kinds of problems would YOU require a calculator for?

3. What are the advantages/disadvantages of using a calculator?

4. Who do you think would benefit from using a calculator?

5. Do you feel that calculators will ever become obsolete? Why or why not? If so, what do you seem them being replaced with?

6. Is there a dependency on calculators on your part? If yes, how do you cope with it?

7. How do you know if your answer is correct? Which do you trust more – yourself or the calculator?

8. Do you think boys use calculators differently than girls?

9. Teach me (or someone who doesn’t know how to use a calculator) a trick or tip about calculator use.
Appendix C:

Problems from Session 3
1. Use the calculator to find the answers to these multiplication questions:

   \[34 \times 34 = \]
   \[334 \times 334 = \]
   \[3334 \times 3334 = \]

2. What do you notice about the multiplication questions and the pattern of answers?

3. Now use the pattern to write down what you think the answer will be to the multiplication question below WITHOUT using the calculator.

   \[33334 \times 33334 = \]

4. Now write down what you think the answer will be to the multiplication question below WITHOUT using the calculator.

   \[3333334 \times 3333334 = \]

5. How did you figure out the answers to questions 3 and 4?

6. Ramesh tells Alison that he multiplied two whole numbers together using a calculator and the answer was 455, but he’s forgotten the numbers. He can remember two things about them:

   - Both numbers had 2 digits
   - Both numbers were less than 50

Alison tries several numbers. She began by putting 7 x 64 into the calculator. But Ramesh said, “I can give you at least three reasons why those numbers can’t be the ones I used.” What were Ramesh’s reasons?
After thinking a bit about the problem Alison made some more tries and found the two numbers. Now you try to find the numbers Alison found. You may use any method you like.

7. Store any 1-digit number in your calculator. Multiply by 3. Multiply by 37. Compare your answer with the original number. Explain.


11. Three people give each other Christmas presents. How many presents all together? What if there had been 4 people? Fill in the chart.

<table>
<thead>
<tr>
<th>Number of People</th>
<th>Number of Presents</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Can you find a formula that gives the number of presents for any group of people?

12. Three people are introduced to each other and shake hands. How many handshakes all together? What if there had been 4 people? Make a chart to show
the number of handshakes for other groups. Can you find a formula that gives the number of handshakes for any group of people?
Appendix D:

Problems from Session 4
1. If a bacterium grows from 2 grams to 20 grams in 16 hours, how much does it grow in half that time? How much does it grow in 32 hours? Can you show this with a diagram? Why isn’t the answer 5 grams?

2. Begin with a rectangle of dimensions 2 by 3 and an area of 6. We want to turn this rectangle into a square keeping the same area as the original square. What would the sides have to be in order to keep this an area of 6?

3. Explore the following claim: “In the newspaper there was an article that stated that the square root of 2 isn’t irrational. What do you think? Is this possible?