What makes Mathematics lessons interesting in the middle school: Student and teacher perceptions

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Abstract

Some researchers have suggested that students in schools find mathematics classes boring, and that this attitude towards learning mathematics gets stronger as students grow older. Using reports of students and teachers, this study investigates how interest is used and developed in intermediate school mathematics classes.

Five teachers and 101 Year 7 and 8 students from a single co-educational suburban state intermediate school participated in the study. One teacher and ten student focus group discussions to explore attitudes to and uses of interest in their mathematics classrooms were audio-taped. The results of these discussions were used to develop themes that formed the basis of separate student and staff questionnaires for all participants. Further data was obtained from a mathematics class journal kept by participants, and from individual interviews with all staff and seven randomly chosen students.

The study showed that both teachers and students had similar ideas about what students found interesting, and revealed several aspects of classroom practices that heightened and/or developed interest in learning mathematics. The most notable of these were: using hands-on activities; teacher enthusiasm; group work and student progress. Mathematical content was rarely seen as interesting in itself, although probability, symmetry and transformations, geometry and problem solving were regarded as the most interesting sub-strands of the curriculum, while number, measurement and 'all of mathematics' garnered least support. Bookwork using textbooks or worksheets was usually considered boring, and activities such as external mathematics competitions and challenging or easy mathematics polarised student opinion.

Interest has a complex and generally positive association with learning. Student reports suggest that two interest factors that have the potential to be used more effectively in mathematics lessons are teacher enthusiasm and group work. The catch phase of situational interest, the aspect of interest most frequently used, was rarely developed further. This study suggests that mathematics learning will benefit from further developing interest in mathematics classes by linking situational interest factors with mathematical content, student experiences and clarity about each student's progress. Teachers need professional development and resource support for this to happen.

Preface and Acknowledgements

This thesis started as a result of my interactions with adult students taking mathematics courses. When questioned about their own learning, the vast majority of their responses related to the emotional aspect of their learning. Furthermore, when learning mathematics, satisfaction with any support received appeared to coincide with a happy and determined look in their eyes—a look of what I would call 'interest'.

I would like to acknowledge the many people who supported me throughout this study. I am very grateful to my principal supervisor, Assoc. Professor Glenda Anthony, who consistently provided ideas, encouragement and professional support in a practical and down-to-earth way. My thanks also go to Dr. Margaret Walshaw for her useful feedback. I am very grateful for the support given to me by the Dean in the Faculty of Science and Technology at EIT Hawke's Bay, Dr. Ken Whittle. Thanks also to Pete, Doug, Vivienne, Alison, Marion and Niki for the work they did so unselfishly to help me to complete my study. To Owen and my other friends and colleagues who cajoled, encouraged and inspired: many thanks for your interest, care and good humour.

I extend my special thanks to the teachers and students who volunteered to participate in this study. These teachers gave so willingly of their time and thoughts and I really can't thank them enough. There were many times throughout the writing process where their evident goodwill sustained me.

Ko te whanau, nga tino kaitautoko: ko Rhys raua ko Jo; ko Bryn ratou ko Tae, ko Miharo, ko Titoki; ko Carwyn raua ko Nikki; ko Rhiannon hoki. Ka aue atu ahau, ka awhi mai ratou. He mihi ki a koutou mo to koutou aroha, me to koutou matauranga.

Hei whakamutunga, ki a koe Chele, taku hoa wahine purotu, nga mihi nui mo to aroha, mo nga pere reka hoki!

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Chapter 1: Introduction

1.1 Background

More than ninety years ago, in 1913, John Dewey published a book entitled *Interest and Effort in Education.* In it he theorised about the idea of interest, and promoted the virtues of interest when learning. He described interest as "not some one thing; it is a name for the fact that a course of action, an occupation, or pursuit absorbs the powers of an individual in a thorough-going way" (p. 65). It took a long time for educational researchers to follow Dewey's lead. The study of affective variables such as interest was sidelined until recently while psychology followed the behavourist, and then the cognitive, paradigms.

Trends in mathematics education have also changed since Dewey's time. As an example, one of the current emphases in mathematics education is *problem solving* (Ministry of Education, 1992). As the problem solving process often involves intense emotional reactions, it was surprising that most of the research into problem solving in mathematics education involved cognitive factors and excluded affective ones (McLeod, 1989). The emphasis on cognition has since changed, with the scale of research into affective factors in general, and interest in particular, having increased during the last twenty years (Boekaerts & Boscolo, 2002).

Dewey's belief that interest and learning are positively related is correct. The results of the research into interest have shown that interest is also related to other affective factors of learning. This means that getting students interested in what they are expected to learn is likely to have positive effects on their learning. Conversely, bored students are likely to have a fewer positive learning experiences.

The results from New Zealand's participation in the Third International Mathematics and Science Study (TIMSS) in 1994 and 1995 and also from the National Education Monitoring Project (NEMP), show that while students often rate mathematics among their favourite subjects in middle primary school, the enjoyment of learning mathematics in schools decreases as students get older (Eley, 1999; Garden, 1996;

1997; 1998). Students appear to lose interest in mathematics as they go through school. This pattern also happens with other subjects, but appears to be more pronounced in mathematics, with many reports that mathematics is boring (Nardi & Steward, 2003; Stodolsky, Salk, & Glaessner, 1991). Furthermore, gender appears to be a factor, with the suggestion that mathematics (Young Loveridge, 1992), or maybe mathematics lessons (Boaler, 1997) are less interesting for girls than for boys.

This does not bode well for the learning of mathematics in schools, especially for girls. If teachers are to improve students' learning prospects in school mathematics then attention needs to be paid to increasing the interest of students in mathematics classes. In order to do this a useful starting point would be to find out about the current attitudes and experiences of both the students and their teachers. This would include what they find interests them in mathematics lessons and also the existing practices relating to using interest in mathematics classrooms.

My experience as a teacher suggests that if we can help increase the interest for students in learning mathematics; if we can reach the stage where we can see the light of interest in their eyes, we can make the school mathematics learning experience for our students and their teachers a more positive one.

It is for the reasons outlined above that I was attracted to this research project.

1.2 Research Objectives

It is plausible that interest has some impact on many aspects of classroom activity, including achievement as well as affective and behavioural variables. Therefore, there is potential for improvements in mathematics education in knowing more about how interest interacts with other classroom factors. As intermediate school is a time when students begin to form attitudes and beliefs that will be the foundation for their adult lives, this is a good stage of life in which to establish, or possibly increase, interest in mathematics classes.

The main aim of this study was to explore the role of interest in learning mathematics for intermediate school children.

The study was specifically designed to achieve the following research objectives:

1. To give a rich description of what intermediate school age children find interests them about learning mathematics.
2. To give a rich description of what intermediate schoolteachers believe is interesting to their students in the mathematics classroom.
3. To find out how teachers use their students' interests in teaching mathematics.
4. To find out what teachers of intermediate school students do in order to make mathematics interesting to their students.

1.3 Overview

The following chapter contains a review of the relevant literature. This review begins by justifying the study of interest in mathematics classrooms, with special attention to the intermediate school stage of development. The way the word 'interest' is used during the study is then clarified, and various forms of interest – individual interest, situational interest, and topic interest – are distinguished, discussed and developed. These concepts are then compared and correlated with other educational ideas such as achievement, learning level, self-efficacy, motivation and goals. Theoretical and practical aspects of using and developing interest within the classroom follow, with particular attention to research from mathematics classrooms. Research literature with respect to interest specifically from the point of view of students, then teachers, rounds off this literature review.

Chapter 3 describes the research design for this study. The next two chapters present the results of the research from student and teacher perspectives respectively. Chapter 6 discusses the results with emphasis on the major findings, presents conclusions and closes the study with suggestions for future research.

Chapter 2: Literature Review

2.1 Introduction

Studies in New Zealand (Eley, 1999; Garden, 1997; Young-Loveridge, 1992) and overseas (Carpenter, Corbitt, Kepner, Lindquist & Reys, 1981; Dossey, Mullis, Lindquist & Chambers, 1988; both cited in Middleton & Spanias, 1999; Stodolsky, Salk, & Glaessner, 1991) show that many children enjoy mathematics during their primary school years, and that this disposition towards mathematics as a subject lessens as the children progress through middle and secondary schools.

The reasons for this may be wide-ranging: from a mismatch between what students like and the way mathematics is taught at each school level, to a build-up of inhibition to learning mathematics, through to a natural changing of interests as children mature. For example, research on intrinsic motivation (which has many features in common with interest) summarised by Lepper, Sethi, Dialdin, and Drake (1997) found that students' reported intrinsic motivation steadily declines from early elementary school through to secondary school.

While this decline in enjoyment and academic intrinsic motivation is not the sole preserve of mathematics but rather is general across subject domains (Anderman & Maehr, 1994; Eley, 1999; Gottfried, Fleming & Gottfried, 2001Slavin, 1994;), many researchers claim that it is more pronounced in mathematics learning than in many other subjects (Eley, 1999; Gottfried, Fleming & Gottfried, 2001; Hidi & Harackiewicz, 2000; Pollard, Triggs, Broadfoot, McNess & Osborn, 2000; Stodolsky, Salk, & Glaessner, 1991) and is especially obvious during middle school (Krapp, 1999; Pollard, Triggs et al. 2000).

Other motivational factors also show negative trends at this stage of development. For example, self-efficacy in mathematics decreases, and becomes more unstable (Eccles et al. 1989). This change is not just due to puberty, but appears to be due to the transition between different types of school structures. There is a direct link between the classroom learning environments before and after the transition from primary to high school and students' levels of motivation and achievement in mathematics (Anderman & Maehr, 1994; Wigfield, Eccles, MacIver, Reuman, & Midgley, 1991).

The middle school is a stage in the development of students when attitudes and academic intrinsic motivation are being stabilised for later life (Gottfried, Fleming, & Gottfried, 2001). Singh, Granville, and Dika (2002, p. 330) commented that "by 8th grade attitudes toward school, patterns of school attendance, and participation in classroom activities are already in existence". Middle school is the time in a student's life when the development of positive attitudes to mathematics learning is very likely to support later study and the development of negative attitudes may restrict career choice (Anderman & Maehr, 1994; Gottfried, 1982).

The decline in enjoyment of mathematics has an effect in classrooms. Teachers report that in both Form 2 and Form 3 (now Years 8 and 9) "uninterested students" and "disruptive students" are among the most common factors that limit how teachers teach their mathematics classes (Garden, 1996, p.74)[1]. Deci (1992, p. 43) noted that "*interest is a powerful motivator*". Perhaps if teachers were able to harness interest within the classroom, some of the abovementioned lack of interest and disruption could possibly be overcome. Increasing interest could perhaps also help decrease the frequency of the phenomenon that Kornfeld and Goodman (1998, p. 308) refer to as "The Glaze".

In order to make productive use of the powerful motivational effects of student interests in the mathematics classroom, and to be able to follow the advice given to "adapt tasks to student interests" (Good & Brophy, 1995, p. 406), it is necessary to find out what students actually do find interesting. However, students have diverse interests. What interests one person may bore another. For teachers to be able to use interest for learning and development in a classroom, activities and content areas must exist that are universally, or at least commonly, interesting. Finding these activities and content areas requires in the first instance a workable definition of interest. From this a thorough understanding of the characteristics of interest can be developed. This can then lead to knowledge of what middle school students find interesting in mathematics classes, how

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1 The most common factors listed by the teachers in Garden's study were "Students with different academic abilities" and "High student/teacher ratio" – neither of which teachers are able to change from within the classroom.

interest can effectively be used in mathematics classrooms, what actions teachers can take to promote and develop such interest and the classroom conditions under which interest can be developed and integrated into the mathematics learning of students.

2.2 Interest

Within the research on 'interest', it is clear that the word interest is used in many different ways (Athanasou, 1998; Krapp, Renninger, & Hoffmann, 1998; Schiefele, Krapp, & Winteler, 1992). Interest is commonly used in phrases such as 'the theatre is interesting', and 'the theatre is one of my interests', where 'interest' has a weaker meaning in the former phrase than in the latter. Schiefele (1991) defined interest in terms of a motivational force relative to specific objects (where 'object' is used in its widest context). Prenzel (1992) defines interest in an object (again interpreted broadly) that focuses on having positive emotions with respect to the object, and activity with the object that seems to have no obvious end in sight – that is simply carried out for its own sake. Athanasou (1998) conceived interest as an actualised state with a variety of positive emotions attached.

Many writers use the phrases 'intrinsic interest' and 'intrinsic motivation' in similar ways. For example, Middleton (1995) uses the terms "intrinsic motivation" and "fun" interchangeably. As he says (p. 254), "the colloquial term 'fun' is better understood by students and teachers (and researchers), and carries connotations of positive affect that 'intrinsic motivation' may not". There are other closely related constructs used in motivational research, such as goals, curiosity, and value. While there is bound to be some overlap between these constructs (Ainley, 2001), interest can be distinguished from these other ideas. The main point of departure is that interest refers to an enchantment, an allure, with an object, whereas intrinsic motivation refers to an inner desire to achieve. It is possible to have such a desire, without the enchantment.

Although the term interest can be thought of in a variety of ways, and has been by different researchers, there are features that are common. One is that interest develops from the interaction of an individual with his or her environment (Schiefele, 1991). Environment should be interpreted liberally here, and may include objects, activities, people, thoughts, hypotheses and events. As interest develops from an individual's interaction with an environment, it is content specific. It has both cognitive and affective components (Krapp, Hidi, & Renninger, 1992). I intend to follow Askell-Williams and Lawson (2001) in adopting Hidi's definition that interest is a psychological state that "involves focused attention, increased cognitive functioning, persistence and affective involvement" (Hidi, 2000, p. 311). This is similar to many students' definition of 'fun' as students who have fun doing mathematics appear to enjoy it and learn more (Nardi & Steward, 2003). Hidi (2000) notes that while focusing attention and increasing cognitive involvement usually involve increased effort, when interest is high these benefits are often made relatively effortlessly. As Dewey (1913, p.15) suggested with respect to the effort needed to learn something in which one is interested: "But this never degenerates into drudgery, or more strain of dead lift, because interest abides".

A useful distinction can be made in this regard. We can distinguish between *individual interest* factors that are centred on the individual, and *situational interest* factors that tend to generate interest in most individuals (Bergin, 1999; Hidi, 1990; Krapp, Hidi, & Renninger, 1992; Mitchell, 1993; Zahorik, 1996). Individual interests are those that take time to develop and have long-lasting effects on an individual's knowledge, skills, and values. Situational interests may occur more quickly in response to the environment, but may have only a fleeting effect on a person's knowledge, skills, and values (Hidi, 1990). While individual interest focuses more on the person, and situational interest focuses more on the object, both forms of interest involve the person-object relationship (Ainley, 2001; Athanasou, 1998; Hidi, 1990; Krapp, Hidi & Renninger, 1992).

A further distinction can be made in the form of another interest factor, *topic interest*. This factor has, under differing circumstances, both individual and situational aspects. Schiefele (1998) used the term topic interest to refer to a form of individual interest related to interest in certain topics. A study by Hidi and McLaren cited by Ainley, Hidi and Berndorff (2002) referred to the situational aspect of interest in topics that were not among students' individual interests. Topic interest can be thought of as having both individual and situational components in varying amounts (Ainley, Hidi & Berndorff, 2002; Renninger, 2000). For example, high reported topic interest may be mainly individual if related topics have high individual interest, or substantially situational otherwise. Wherever it is encountered this study will discuss topic interest in terms of the individual and situational components and their interaction.

Individual interests are not the same for all students. This term describes the preferences that are specific to an individual, that develop slowly and last over time for specific activities or content areas. While relatively stable, individual interests are not fixed. They change as an individual develops (Krapp, Renninger, & Hidi, 1998; Renninger, 1998; Renninger, 2000) especially during middle school. We need to conceptualize individual interest as a continuum from well-developed through less-developed that "refers to a continually evolving relation of a person and particular subject content" (Renninger, Ewen, & Lasher, 2002).

Individual interest includes both stored knowledge about a subject, as well as stored value. Stored knowledge relates to not just knowing facts, but also to being able to communicate ideas and work within the culture of a subject area. Stored value relates to valuing the content of a subject area as well as affective aspects such as self-efficacy, enjoyment, and also frustration, as interest develops (Renninger, 2000). These two components, stored value and stored knowledge, are not independent, but interact with one another (Renninger, 2000; Renninger, Ewen, & Lasher, 2002). Furthermore, both components are needed to develop individual interest to the well-developed stage, epitomized by asking and seeking answers for questions such as "why isn't $(a + b)^2$ equal to $a^2 + b^2$?".

Individual interest is characterized by individuals following their own interests. While these interests, once developed, are quite stable, they need to be actively developed and maintained. Conditions such as challenge or curiosity might begin the development of an individual interest. The interest will develop further with action, provided the individual maintains the conditions that foster interest. For example, an initial interest in playing tic-tac-toe may be due to trying to understand the game, or the enjoyment of winning. Once the student, or his/her opponent discovers the optimal strategy, the interest may diminish. Provided the stored knowledge continues to be extended, and the conditions for individual interest development are maintained, the interest will develop over time (Renninger, 2000).

When a student develops an individual interest the actions taken by the student in developing that interest are focused on the object of interest. Developing an individual interest involves use of deep learning strategies – and produces qualitatively different learning than when individual interest is less developed. Everyone has their own idiosyncratic individual interests. Even when two individuals have a well-developed interest in World Cup Soccer for example, the allure, and hence the focus for each person, and the actions taken to develop that interest, are different (Renninger, 2000).

Situational interest has different properties to individual interest. It refers to aspects that are often interesting to most people, or at least to a large minority. Such aspects could be activities, domains of knowledge, or stimuli from the individual's environment. Situational interest is generated by stimuli in the environment that grab one's attention, is more likely to have an immediate emotional appeal to most people present, and may be quite transitory. (Hidi & Harackiewicz, 2000; Murphy & Alexander, 2000). The affective appeal may be either positive or negative (Iran-Nejad, 1987). For example, the effects of a storm may be interesting without being enjoyable. In contrast to individual interest, situational interest usually happens spontaneously, is short-term and unstable (Hidi, 1990; Hidi & Harackiewicz, 2000; Murphy & Alexander, 2000). Examples of factors that induce situational interest include novelty or surprise, discrepancy, sex and violence. Situational interest may develop into individual interest over time (Hidi & Harackiewicz, 2000).

One aspect of situational interest that has been widely researched is text-based interest (Goetz & Sadoski, 1995a; Goetz & Sadoski, 1995b; Wade, Alexander, Schraw & Kulikowich, 1995; Wade, Schraw, Buxton & Hayes, 1993). Text that includes certain factors such as those listed above, as well as things like ease of comprehension, personal identification, and passages that are logically structured, increase situational interest (Hidi & Harackiewicz, 2000; Wade, Schraw, Buxton & Hayes, 1993).

Krapp, Hidi, and Renninger (1992) suggested that situational interest can sometimes be a catalyst for individual interest to develop. Hidi (2000) gives an example of how this can happen. She cites the theoretical case of a student with no background in psychology who becomes fascinated by an exciting lecture about Freud. While completing the required readings, simply because they are necessary for the coursework, using the language of Mitchell (1993), her situational interest is "caught" and "held". As a consequence "she becomes fascinated with Freud's personality theory. She reflects on the theory and relates it to her personal experiences. She becomes excited, wants to know more and, as she continues to read develops her own assumptions and hypotheses about the behaviour of significant others in her life" (Hidi & Harackiewicz, 2000, p.153). In short, the student has developed an individual interest in an aspect of Freud's work.

Situational interest and individual interest do not form a dichotomy of interest. In any given instance, both forms of interest may be placed on a continuum between well-developed and less-developed (Hidi, 1990; Hidi & Berndorff, 1998; Hidi & Harackiewicz, 2000). Situational interest and individual interest are not independent facets of interest, but continually interact with each other to raise or lower the overall level of interest (Alexander, Jetton, & Kulikowich, 1995; Bergin, 1999; Hidi, 1990; Hidi & Harackiewicz, 2000) as the example of the psychology student above illustrates. Furthermore, interest is multifaceted (Mitchell, 1993), and one may therefore attend to each of the facets separately.

Mitchell developed a model for situational interest for secondary mathematics classrooms. He chose situational interest due to the influence teachers are able to exert on this form of interest, and secondary mathematics education for the reasons of decreasing interest over time advanced earlier in Section 2.1. He distinguished between *catching* interest, involving ways to stimulate individuals, and *holding* interest, which he described as empowering. His multifaceted model divided situational interest into catch facets of *puzzles*, *group work* and *computers*, and hold facets of *meaningfulness* and *involvement*. He noted that "none of the catch facets in and of themselves, however, appeared to serve as an effective way to maintain student activity" (p. 427). The catch facets all add variety or unusualness to the normal classroom activity. Puzzles are activities that stimulate curiosity, group work stimulates communication (which is needed in mathematics learning as students see mathematics as difficult to learn independently of others (Stodolsky, Salk, & Glaessner, 1991)), and computers enable students to test conjectures and explore. The hold facet involves different aspects of empowering students. Holding interest occurs when the objects under consideration hold *meaning* in a student's life, and when students are *involved* as active participants in learning.

While the two facets of situational interest were postulated by Mitchell, he did not suggest how these facets might be able to be developed into individual interests. The development of interest was the subject of a theoretical analysis by Krapp (2002). In this model Krapp suggested three steps to development of an individual interest, such as the hypothetical case of the psychology student previously mentioned. The first two were the catch and hold aspects of Mitchell's situational interest, followed by individual interest itself. Krapp suggests that there are two types of factors that are essential in the development and maintenance of interest. These are cognitively represented factors, such as personal values and goals; and feeling-related experiences. Krapp contends that both the transitions, from catch to hold, and from hold to individual interest, are only possible provided ***both*** the cognitive and affective factors are experienced together in a positive manner. As this theory is still untested, further research is necessary to verify the model, "in particular regarding the role of teaching and instruction in facilitating or hindering interest development" (Boekaerts & Boscolo, 2002, p. 379).

The one facet mentioned by Mitchell that does not seem to come up in other explications of situational interest is computers. Hannafin, Burruss, and Little (2001) noticed that students were interested when they used the computer program Geometer's Sketchpad with middle school students using an open-ended learning environment technique. They commented in particular that the program enabled the students an element of choice and to work at their own pace. Computers may be a catch factor of situational interest for these reasons, rather than a facet per se.

2.3 The Value of Interest in Learning and Development

Educational psychologists and leaders alike promote the use of intrinsic interest to motivate students to learn (Good & Brophy, 1995; Gottfried, 1982; Lappan, 1999; Renninger, Hidi, & Krapp, 1992; Slavin, 1994). We participate more often, more fully and longer in activities related to objects that interest us and from which we gain satisfaction and enjoyment (Hidi & Berndorff, 1998). As a consequence, Good and Brophy (1995) urge "teachers to select or design academic activities that students engage in willingly because they enjoy them or because the activities incorporate content that the students are already interested in" (p. 405).

Many researchers claim that academic achievement is improved when learners are more interested (Hidi & Harackiewicz, 2000; Hoffmann, Krapp, Renninger & Baumert, 1998; Renninger, 1998; Schiefele, 1998). In one example, Alexander and Murphy (1998) found that for students of educational psychology those with high initial interest and only moderate domain knowledge tended to outperform those with initially higher domain knowledge but lower levels of interest. This adds emphasis to Renninger's (1992) view that for learning development interest is more important than prior knowledge of content. Achievement in mathematics is singularly associated with high intrinsic motivation, which is closely related to individual interest (Gottfried, 1985). In a study of talented middle school students, interest in mathematics was found to be a significant, albeit moderate, predictor of achievement (ability was better), whereas achievement motivation was not (Schiefele & Csikszentmihalyi, 1995). In order to improve achievement in mathematics, Ma (1997) suggested that, rather than trying to make difficult mathematical content easy to learn, which has very little impact on achievement, teachers should ensure that such content is presented in an interesting, attractive and enjoyable way.

Schiefele, Krapp, and Winteler (1992) conducted a meta-analysis of the research looking at the relationship between interest and academic achievement. They found that such analysis was problematic given the variation in the definition of interest and the lack of controlling for variables such as ability. Their meta-analysis is restricted to individual interests directed to specific subject areas in school settings, and is restricted to correlational studies only. The only study in the meta-analysis for which causal inferences could be made (one by Eisenhardt in 1976) showed that while interest had an effect on later achievement, an even greater effect of achievement on later interest was found (Schiefele, 1998), lending weight to the assertion by Schiefele and Csikszentmihalyi (1995) that "interest and achievement mutually influence one another" (p. 177). Of the 121 independent correlation coefficients in their study they found an average correlation coefficient between interest and achievement of 0.31 (standard deviation = 0.133). All correlation coefficients were positive. They concluded that level of interest accounts for approximately 10% of the observed variation in achievement. The only significant differences between subjects that became apparent were that biology and literature had lower correlation coefficients than other subjects (although still significantly above 0). Grade level and natural science/social science comparisons showed no significant differences between groups. However the results of this meta-analysis showed a significant difference between male and female students. Interest explained about 12% of the observed variation in achievement for males, but only half as much for females.

Similar results were found in the meta-analysis by Ma and Kishor (1997) into the relationship between achievement in mathematics (AIM) and attitude to mathematics (ATM), where a significant (at the 0.01 level) but small association was found between ATM and AIM. Ma and Kishor assessed the corresponding causal relationships and once again found a significant and positive, albeit small, causal relationship whereby ATM increased AIM, whereas the reverse relationship was not significant. This meta-analysis unsurprisingly concurred with the majority of studies researched by Ma and Kishor that any causal relationship that exists between ATM and AIM is likely to be weak and have few educational implications. A recent study into the effect of interest and other variables in mathematics and science achievement indicated that interest affects achievement both directly and indirectly through academic time or homework (Singh, Granville, & Dika, 2002).

Other researchers (e.g. Wolters & Pintrich, 1998) see little evidence of this positive correlation between interest and achievement. This shows an apparent divergence of opinion expressed in the views of researchers. This difference is possibly due to the way interest is used in classrooms in learning situations. When interest is aroused that does not support the important ideas and skills to be mastered, such as in the case of 'seductive details' in text (see more later in this section) (Harp & Mayer, 1997; Hidi, 1990; Wade, Alexander, Schraw, & Kulikowich, 1995; Wade, Schraw, Buxton, & Hayes, 1993), or when it is used gratuitously as an end in itself (Zahorik, 1996), it has the potential to distract from the main purpose of learning. Baker, Herman, and Yeh (1981) suggest that whatever objects or activities that are added to make the situation more interesting need to have incentive value for the learner, be pertinent to the learning, and reinforce the main ideas and not be distracting.

The varying relationships between interest and learning noted in the results of the studies mentioned above, are possibly explained by the degree to which the type of interest is situational or individual. Learning is often improved for tasks for which a student has an individual interest (Alexander, Jetton, & Kukilowich, 1995; Alexander & Murphy, 1998; Renninger, 1992; Renninger, 2000; Schiefele, 1991). However, this is not a simple relationship, as higher interest alone is not always associated with higher achievement (Alexander & Murphy, 1998; Renninger, 1992; Renninger, 2000). Individual interest in an object is accompanied by a greater variety of activities associated with the object than for cases where individual interest is lacking. This means that when performance is measured by tasks that a student has explored due to their individual interests, an increase in performance can be expected. On the other hand, if such measurement of performance is made using a task that a student's individual interest diverts her or him from, no similar increase is likely.

Whether or not academic performance as measured by classroom assessment is improved when students are interested, it is clear that interest has a "powerful facilitative effect on cognitive functioning" (Hidi & Berndorff, 1998). Varying levels of interest changes the quality of learning. Interested students appear to use more deep learning strategies (Alexander & Murphy, 1997; Hidi, 1990; Hoffmann, Krapp, Renninger & Baumert, 1998; Schiefele, 1998; Tobias, 1995), persist longer with more positive feelings and greater willingness to learn (Ainley, 2001; Krapp, Hidi, & Renninger, 1992; Tobias, 1994), and have a better quality of experience in learning mathematics (Schiefele & Csikszentmihalyi, 1995) than others. Renninger, Ewer and Lasher (2002), in providing contexts in line with students' individual interests, suggested that a well-developed individual interest enabled students to interact with the reading and mathematical word problem solving content in their study in terms of sense-making to gain greater understanding than when interest is low. In their 1998 study, Wolters and Pintrich found that of the three motivational components, task-value and interest, self-efficacy, and test anxiety, the best predictor of use of deeper learning strategies was task-value and interest.[2] Pintrich, Ryan, and Patrick (1998) found that 7 to 9th grade students who were more interested in a subject were more likely than others to develop self-efficacy and use deeper cognitive processes and metacognition,

[2] On the other hand, the factor most closely related to classroom performance was self-efficacy.

regardless of gender. Moreover, interest has been significantly positively associated with a range of affective variables such as experiencing potency, self-esteem, intrinsic motivation, perception of skill, positive affect, increased concentration, and feeling active and excited (Krapp, 1999; Schiefele & Csikszentmihalyi, 1994).

Interest is not the only factor that influences the quality of learning. Alexander and Murphy (1997) note that during the process of learning, levels of knowledge, motivation, interest, goals and strategic processing all vary, and influence academic performance. They suggest using a coordinated approach paying attention to all these variables, rather than targeting one factor at the expense of the others. While the evidence cited above linking interest and academic performance shows a complex relationship of interest with many motivational and environmental factors, the evidence may be taken as a whole to show that using interest has potential in helping students learn (Schiefele, 1998; Hidi & Berndorff, 1998; Askell-Williams & Lawson, 2001).

The discussion above deals predominantly with the value and uses of individual interest. The distinction between individual interest and situational interest leads to an analysis of the value of situational interest. One way in which situational interest differs from individual interest is that it can be triggered within many individuals, often at the same time. Thus, situational interest has a greater potential than individual interest to be used in classrooms for many students at a time. If we can then find the mechanism(s) for developing situational interest into individual interest (Mitchell, 1993) the benefits of both types of interest are available.

Research on text-based interest, a form of situational interest, shows that text containing factors that make it interesting, produce better recall (Goetz & Sadoski, 1995a; Harp & Mayer, 1997; Hidi & Harackiewicz, 2000; Shirey & Reynolds, 1988; Wade, Schraw, Buxton & Hayes, 1993). Much has been made of the concept of *seductive details*; interesting but unimportant information in the text. Early claims that the interest in seductive details diminished the recall of important points in text articles were debated by academics. Wade and her fellow researchers (1993; 1995) claimed that the research showed evidence of a significant seductive detail effect: "there is documented evidence that information that rates high in interest but low in importance to the main ideas or themes of a text is recalled more often and receives more attention than its importance would seem to warrant" (Wade, Alexander, Schraw & Kulikowich, 1995, p. 513). Goetz and Sadoski (1995a; 1995b) suggested that the evidence for this effect was flawed, and that there may well be no such effect.

The debate appears to have been settled by experiments by Harp and Mayer (1997, 1998). They showed that not only did seductive details have a detrimental effect on recall of important points in descriptive passages, but that these details, as well as seductive illustrations, have the same sort of effect for explanatory passages (using scientific explanations) on understanding, for example, problem-solving transfer (Harp & Mayer, 1997). Furthermore, the deleterious effects of seductive text and seductive illustrations are compounding. Their experiments, with some minor caveats, show that seductive details divert attention and recall from the main points by activating "irrelevant prior knowledge, which the reader then uses as the organizing schema" (Harp & Mayer, 1998, p. 431) for learning. They suggest that delaying introducing seductive information until after the important ideas are presented is one way to mitigate the damaging effects of seductive details on learning. An alternative would be just leaving out the seductive details altogether.

In what could be a specific instance of the use of seductive details, Zahorik (1996) noted teachers commonly using situational interest factors in classrooms in order to raise the interest level in their classes. He further noted that "at least one-third [of the interest-raising activities] were hands-on activities that seemed gratuitous in whole or in part" (Zahorik, 1996, p. 556). Zahorik suggested that interesting activities that are not overtly connected to curriculum objectives act like the seductive details in text-based media, and have a similar distracting effect from the content to be learned. He argues for future research into how to integrate the use of interesting activities and content ideas into effective learning practice.

2.4 Interest and Motivation

When someone performs an activity purely and simply for the personal satisfaction and enjoyment derived from the activity itself, we say that person is intrinsically motivated . Extrinsic motivation on the other hand is when an action is taken in order to gain some other reward, such as money, praise, or even getting the better of someone else (Deci, 1992).

Throughout the literature, the ideas of interest and intrinsic motivation are often referred to together (Wigfield & Eccles, 2000; Boekaerts & Boscolo, 2002). As mentioned earlier (Section 2.2), it is possible to have the inner desire to act, the intrinsic motivation, without the fascination that is a part of individual interest. There is considerable overlap in the two constructs. If one has an individual interest in a particular object, one is more likely to be intrinsically motivated with respect to that object. For example, choice and challenge are factors that improve intrinsic motivation, and these are also factors that enhance interest (Hidi & Harackiewicz, 2000). Sansone and colleagues (1992) demonstrated with undergraduates that increasing interest was the best way to increase motivation for persisting with an initially boring task. Furthermore, Hidi and Harackiewicz suggest that the relationship between interest and intrinsic motivation may be recursive. Increasing interest, leading to increased intrinsic motivation, leading to increased knowledge developing individual interest and so on.

Extrinsic motivation is also related to interest, but in a different way. Early studies of the effect of extrinsic motivation have seemingly conflicting results. Some showed that using extrinsic rewards such as money, praise, avoidance of punishment, deadlines, imposed goals, and competition were all associated with an average decrease in intrinsic motivation and interest. McGinnis, Friman, and Carlyon (1999) showed that the effects on middle school students of extrinsic rewards for doing mathematics problems can be quite variable, with time spent on mathematics sometimes reducing markedly after the reward conditions were discontinued. However, other studies showed that rewards such as providing choice or acknowledging feelings increased intrinsic motivation and interest. According to Deci (1992), the difference between the two apparently contradictory results is that those extrinsic motivation approaches that enhance autonomy are associated with increased interest and intrinsic motivation, whereas those that are perceived as controlling have the opposite effect. As with situational interest, extrinsic motivation may be used to engage students in activities that are initially seen as uninteresting.

Hidi (2000) contends that the early research involved short-term or simple activities. The true situation may be more complex for more complex tasks. When initially interesting and boring tasks are analysed separately, extrinsic rewards do not appear to reduce intrinsic motivation for initially uninteresting tasks. This gives support to the idea that extrinsic rewards could be used to increase interest and motivation for initially dull tasks (Sansone et al. 1992).

Just as viewing situational interest and individual interest as a dichotomy of interest has been discredited, viewing extrinsic motivation and intrinsic motivation as a simple dichotomy of motivation also appears to lack foundation (Hidi & Berndorff, 1998). Using self-determination theory, Deci (1998) describes how extrinsic motivation can become internalized (take on personal importance) and finally integrated (where the motivation is completely volitional). Hidi and Berndorff (1998, p.78) further suggest "that situational interest may be an externally triggered process that goes directly to the heart of integration", and that this integration may alter both the affective and cognitive domains. Thus using situational interest may present a direct way of increasing intrinsic motivation and individual interest. Furthermore, as intrinsic motivation and anxiety are negatively correlated (Gottfried, 1982) suggested that using situational interest in this way may have the additional advantage of reducing anxiety. Sciutto (1995) successfully used this approach with undergraduate psychology students taking a statistics course.

2.5 Interest and Goals

Achievement goals can be defined as "integrated patterns of beliefs and attributions that represent the purpose of achievement behavior and influence how individuals approach, engage in, and respond to achievement tasks" (Hidi & Harackiewicz, 2000, p. 160). There appear to be two types of achievement goals: *Mastery goals* that orient people towards mastering new skills, developing 'relational understanding' (Skemp, 1987), and developing competence; and *performance goals* that orient people towards doing better than others, seeking positive affirmation and avoiding negative evaluations of ability, and valuing ability rather than effort in performance.

Initially mastery goals were given a good press with respect to learning, and the opposite was the case for performance goals. Use of mastery goals was positively correlated with deep cognitive processing, choosing challenging tasks, involvement in learning, and effective study, among other things, while performance goals were correlated with lack of effort, surface learning strategies, and negative attitudes (Anderman & Maehr, 1994; Hidi & Harackiewicz, 2000). As researchers in this area became more sophisticated in their analysis, it became clear that there were often positive effects for performance goals. Hidi and Harackiewicz (2000) report the research of Midgley and colleagues in which performance goals are divided into extrinsic goals, focussed on obtaining external rewards or avoiding external punishments, and relative ability goals, where the focus is on outperforming others (so the emphasis is on improving performance). Hidi and Harackiewicz (2000) also report the research of Elliot and others wherein performance goals are divided into performance-approach goals – aimed at outperforming others (similar to relative ability goals) and performance-avoidance goals in which the aim is to avoid failure. In these formulations, the theory is that the outperforming others goals lead to improved performance, whereas the other type of performance goal is linked with negative effects on learning.

It appears as though goals and interest are related constructs. Students who have an individual interest in a specific subject may well be more likely to have mastery goals than performance goals (Murphy & Alexander, 2000), and students who have mastery goals, when consequentially developing their knowledge and skills in a subject, are more likely to develop individual interest in that area (Hidi & Harackiewicz, 2000). According to Pintrich, Ryan, and Patrick (1998) the second half of this reciprocal relationship between interest and mastery orientation appears more pronounced for females than with males. Other factors affect the relationship between goals and interest. Different types of goal usage (mastery goals, performance goals, performance-approach goals, and multiple goal types) have been shown to be optimal in promoting interest relative to developing or using skills, individual orientation to achievement, and context (Hidi & Harackiewicz, 2000).

2.6 Interest Within the Classroom

In this section, the complex relationships between using and generating interest, and classroom learning, are discussed, with a view to informing classroom practice. The distinction between situational interest and individual interest that was noted earlier is important in this discussion, which will examine the various ways that both these types of interest can be used in classrooms to support learning. Furthermore, classroom activities can generate, develop and sustain various types of interest, which in turn can be used to facilitate learning.

Although both individual and situational interest have an impact in the classroom, they require different consideration (Hidi & Harackiewicz, 2000; Hoffmann, 2002; Krapp, 1999; Mitchell, 1993; Renninger, 1998; Renninger, 2000). In practice it is not immediately obvious how individual interest can be effectively used in classrooms. Zahorik (1996) objects to using individual interest in the classroom because "coming to know the interests of each student in a class and then developing personal programs in relation to the interests is a formidable task" (pp. 552-553).

While it may be difficult for teachers to know and use the individual interests of all students, some individual interest factors may be able to be used within classrooms. Individual factors that generally influence interest are:

- belongingness (including cultural value; identification – based on gender, ethnicity, religion, etc; and social support – recognising and supporting the interests of friends and relations)
- emotions (either positive or negative towards specific content),
- competence ("Am I likely to get good at this?")
- utility-goal relevance ("Will this help me achieve my goals?"), and
- background knowledge (people are often more interested in subjects that they know a lot about)—including gaps in their knowledge ("Oh, I didn't know that") (Bergin, 1999).

At least some of these can be positively incorporated into the classroom programme.

Developing personal programmes as a consequence of knowledge of students' individual interests is not the only way to harness interest. In addition to using individual interests as an aid to normal lessons (Renninger, 2000) classroom teaching can have an effect in developing individual interests (Krapp (1999).

One way of using individual interests within lessons is to note that interests change as children develop (Renninger, 2000). This means that choosing activities and content relevant to the current developmental stage of the student will increase the chance of appealing to individual interests of at least some students in the classroom. Furthermore, if these tasks and activities are based in meaningful contexts, are common enough that students can start with something they know, and complex enough that working and discussing with others will result in a deeper understanding, there is a benefit to learning for all involved.

Moreover, since individual interests vary from child to child, using a variety of scenarios in teaching enables at least some individual interests to be accommodated in classrooms. Giving students choice in the topics they study can achieve this variety, and has been observed to lead to greater classroom interest (Bergin, 1999). Renninger (2000) also suggests encouraging an active learning approach by exposing students to potentially interesting activities and content. Follinger-Albers and Hartinger (1998) showed that by combining these two aspects classrooms can be organized to use individual interests. Students in their study were more likely to have interests relating to material from school subjects when they were allowed to be active and choose their own topics for study at school.

Another means of using existing individual interests in classrooms is highlighted in a review of research on interest and motivation by Hidi and Harackiewicz (2000). In this review they note that people "who are interested in particular activities or topics pay closer attention, persist for longer periods of time, learn more and enjoy their involvement to a greater degree than individuals without such interest". Teacher observation of this type of behaviour by students can be indicative of their individual interests, enabling the introduction of new concepts, topics, skills and activities related to this knowledge of individual student interests. In this way, individual interest may be used to facilitate learning in the classroom.

On the other hand, individual interests can be affected by classroom teaching, although not much is known about how to nurture individual interests, and not all individual interests are easily amenable to development in a school setting for academic learning (Hidi & Berndorff, 1998). Bergin (1999) suggests that exposure is a prerequisite to developing an interest in something, arguing that if one has no exposure or awareness of a particular domain it would be impossible to be interested in that domain. Thus exposure provides another reason for using a variety of contexts in classroom activities. Significant others, for example parents, peers, family members, and teachers, have an opportunity to increase interest in certain content and activities (Mitchell, 1993; Renninger, 1998). Although teachers may have little influence over the individual interests that their students bring to the classroom, they may be able to develop tactics that have an effect over time on the individual interests that students take with them.

For these reasons, Bergin (1999) suggests that teachers plan with the individual interest factors in mind, but acknowledges that this will not be enough to interest all students. However, situational interest can occur for many students at the same time, so situational interest, rather than individual interest, may be more significant in a classroom (Bergin, 1999; Hidi & Berndorff, 1998; Zahorik, 1996). Bergin even goes so far as to say that "only situational interest is manipulable by educators, at least in short-term encounters" (p. 87).

Situational factors that influence interest in a classroom include:

- hands-on
- discrepancy (or cognitive conflict)
- novelty
- food
- social interaction (working with others – particularly friends) – including visible author (where the author of an item to be studied uses first person and personal anecdotes)
- modelling (either of high profile others, or of enthusiastic teachers)
- games and puzzles
- content (some topics are more interesting than others)
- biophilia (natural features of the environment; for example, having fish tanks in the classroom)

- fantasy (preferably endogenous rather than exogenous)
- humour (even when the humour is unrelated to the content to be learned)
- narrative (telling stories) (Bergin, 1999).

Bergin (1999) also suggests that it is possible to add 'cultural value' to this list provided many students in a class share a similar culture or subculture. In such cases, teachers can then rely on most students within that particular subculture to have similar interests with respect to that subculture. In addition, Deci (1992; 1998) suggests that interest needs the underpinning ideas of competence, autonomy, and relatedness. Lepper and others have identified challenge, curiosity, control and fantasy (Lepper & Cordova, 1992; Lepper & Henderlong, 2000). Zahorik (1996) identified *student trust* as one factor that teachers used to increase interest in their classrooms, supporting the inclusion of Deci's *autonomy* and Lepper's *control.* In studying situational interest in middle school Freeman, McPhail, and Berndt (2002) captured three dimensions of situational interest—distractability, diverse representations, and skill.[3]

Developing classroom learning environments by using materials and tasks that include such factors as those above aids the situational interest component in a student's learning (Hidi & Harackiewicz, 2000; Lepper & Cordova, 1992; Mitchell, 1993). Teachers may therefore plan to use these situational interest factors mentioned to enhance interest even in classes where individual interest cannot be used. As a consequence, using situational interest in the classroom reduces the barriers to participation in learning. Examples of this are that previously uninterested and unmotivated students may find situational interest provides access to learning (Hidi, 1990; Hidi & Berndorff, 1998; Hidi & Harackiewicz, 2000) and that situational interest factors can also provide a basis for learning specific subject content that even motivated students may have initially found uninteresting or even boring (Bergin, 1999; Mitchell, 1993). This is especially pertinent with respect to teaching mathematics as students are often reported to find mathematics classes tedious (Nardi & Steward, 2003).

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3 The authors themselves note that a weakness in their study methodology may have caused student ideas on situational interest to be confounded with how they learned.

There is a range of research studies that focus on factors influencing situational interest. Hoffmann (2002), in a study of the relationship between interest, self-concept, and performance in Physics classes, reported that working in single-sex classes for at least some of the time increases both situational interest and achievement for some girls, and reduces the documented loss of interest over time in both genders.[4] Johnson and Johnson (1985), using the situational interest factors social interaction (cooperative groups) and discrepancy (controversy), improved the learning of handicapped students. Tobias (1995) reports improved metacognition in lower-ability mathematics students (although not in others) when using specific situational interest factors. Bicknell and Stevens (2000) advocate the use of games and puzzles, and posing challenging problems for children who are mathematically gifted—as a way in which caregivers and teachers can participate in stimulating and maintaining situational interest in mathematics.

Other research examples of using situational interest noted in the literature include: female college students who found that *visible author* in statistical texts had a beneficial effect on understanding, intrinsic motivation and affect (Nolen, 1995); and 8-10 year old mathematics students who found that embedding instructional materials in *fantasy* contexts increased interest, immediate recall, and retention. Even though there was no immediate significant advantage in performance on more general mathematics skills for the fantasy group, significant improvement was evident in the posttest two weeks later (Parker & Lepper, 1992).

Getting students interested is often a key factor in the decisions teachers make in choosing topics and presenting material to students (Zahorik, 1996). Hilari Hinnant (1999), a first-grade teacher in Virginia, in her offer of advice about exciting her young proteges in learning mathematics includes references to using interest. She suggests ways of using biophilia (the mathematics of gardening), making mathematics meaningful, keeping avoiding mathematics anxiety (Stodolsky et al. 1991), making connections, working with others, making hands-on discoveries, choice, and fantasy. That the suggestions of an experienced and energetic teacher echo many of the research-based ideas above seems to this researcher to at least partially validate both paradigms.

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4 The single-sex classes in these studies made use of contexts that were different for boys and girls. It may well have been the different contexts that had the effect on interest.

Other examples of this are: the use of counterintuitive problems (discrepancy in Bergin's terms) (Maylone, 2000); use of biophilia and group work (Morita, 1999), probability games (van Zoest, 1997), group work and challenge (van Zoest, 1998), and group work and choice (Wiest, 2000).

Gender differences have been associated with both situational and individual interest. According to Hidi and Berndorff (1998), boys seem to be more affected by situational interest than girls. Furthermore, the meta-analysis conducted by Schiefele and colleagues (1992), noted that the effect of individual interest on achievement was about twice as much for boys than for girls.

Teachers are also able to manipulate the social context of the classroom in order to inject situational interest factors. Ainley (2001) suggests using cognitive conflict to arouse interest by looking at things in surprising new ways, and giving opportunities to investigate these surprises. Working with peers is another situational interest factor that can be used. This factor can sometimes appear to decrease productivity due to social distractions. A resolution of this apparent contradiction was offered by Ainley who noted that in some situations individuals may be distracted while in other situations these same individuals may be involved and interested, as it is the person-object relationship that is crucial in arousing and developing interest (also Hidi, 1990). On balance, group work generally has a positive effect on learning. Zajac and Hartup (1997) reported productivity increases when using friends as coworkers, and cooperative learning groups are also reported to produce benefits for learning (Johnson & Johnson, 1995; Pressley & McCormick, 1995; Slavin, 1990; 1996). Pressley and McCormick (1995) list four criteria for effective cooperative learning: learning needs to be interdependent; students should interact face-to-face; individuals must be accountable; and students must be taught interpersonal and group skills. Structuring social interactions in this way they claim can lead to increased intrinsic motivation, interest and meaningfulness, especially over the long-term.

Another approach to increasing situational interest is to use self-regulation strategies to adapt tasks. In the intriguingly titled article "Once a boring task always a boring task?", Sansone and others (1992) found that where intrinsic motivation for a task was lacking, but there was a desire to achieve, subjects were able to employ self-regulatory strategies that increased interest, which then increased the chance of continuing with the previously boring task. They identified strategies such as increasing the skill or challenge in a task, using artistic or creative elements present, choosing a different and more interesting context, and varying the procedures used in doing the task as possibilities for increasing interest. Furthermore, they compared a variety of strategies for increasing motivation: rewarding oneself, noting that an activity was 'good for you', increasing interest (using one of the self-regulatory strategies above), getting positive competence feedback, and using no additional strategies. Over a variety of activities, the participants rated increasing interest as significantly better than other strategies for persisting with a once boring task.

Bergin (1999) cautions that "although most teachers aspire to increase the interest of their students, they should keep in mind the fact that interest enhancement does not necessarily lead to learning enhancement" (p. 96). Likewise Zahorik (1996) notes that the use of situational interest in the classroom often seems to be an end in itself, with no deeper educational end envisaged. Interest-raising activities that are recommended to improve the prospects of enhanced learning are those that are endogenous to the learning objectives (Bergin, 1999) and use content that is intrinsically appealing to students (Zahorik, 1996).

For situational interest to have any chance of developing into individual interest, and thus take on the lasting qualities that are the strength of individual interest in terms of learning, it is necessary to maintain the original situational interest and develop it further. Mitchell (1993) suggests that there are two facets to situational interest, which he termed the *catch* and *hold* facets. He proposed "that the essence of catching lies in finding various ways to stimulate students, whereas the essence of holding lies in finding variables that empower students" (p. 426).

The situational interest factors that have been discussed so far are those that catch interest, rather than hold interest. Mitchell suggests that *empowerment* is the main principle by which the hold facet of situational interest can be initiated, and proposes two main facets of empowerment: meaningfulness and involvement. A topic or task is meaningful to students if it appears relevant to the personal knowledge and goals that the students have. Students are involved when they are active participants in learning process. For example, Evered (2001) describes how she used puzzles (brainteasers/ riddles/paradoxes) with group work to catch interest, and then developed meaningful contexts in order to maintain this interest.

2.7 Interest Within the Mathematics Classroom

In the previous section, ways of using and developing both individual interests and situational interest in classrooms were identified. The focus for the current section is specifically on the implications within mathematics classrooms. While the material contained in section 2.6 remains relevant, only features that have particular reference to mathematics classrooms will be reported in the present section.

With respect to using individual interests in mathematics, the context plays a big part in both the degree of interest (Krapp, Hidi, & Renninger, 1992; Renninger, Ewen, & Lasher, 2002) and in the effectiveness of learning. Students learn better in contexts that are familiar and realistic (Ministry of Education, 1992). Provided there is a match between the context for the mathematics to be taught and a student's individual interest or personal knowledge, what Mitchell (1993) describes as meaningful, interest will play a role in both the quantity and quality of learning.

However, the very nature of individual interests means that what is a relevant and interesting context for one student is not necessarily as interesting for another student. Also when teachers choose contexts that they believe to be relevant and/or interesting they often get it quite wrong, as the following illustrates:

> Most of the students in this study, however, did not seem to share this perception with regard to most of the contexts used in practical and investigative mathematical activities in which they were asked to participate in their lessons. The students' resentment seems to be directed quite acutely towards some of these activities. … Vicky and Yianna do not seem to see through fence designing or table manufacturing an opportunity for practising and developing certain algebraic and geometrical skills that are transferable to contexts that are *personally* relevant to them. (Nardi & Steward, 2003)

Moreover, far from linking content to individual interests and knowledge, Zahorik (1996) noticed that teachers use many exogenous tactics to get learners to be interested in the content that they study. Use of hands-on activities, including games, puzzles, and projects, was common among the teachers in his study, even when the activities had little to do with the content they needed to teach. Zahorik concluded that the main purpose of many of the hands-on activities was to keep the 'boring' content at bay, and focus on the pleasure of the activity. One down-side of this approach is that the standard mathematics classroom content becomes associated with lack of interest.

Many of the factors suggested for use as situational interest factors can either be used simply as catch factors in mathematics classrooms, or they can be extended to gain more benefit from the interest developed. For example, Zahorik (1996) noted that hands-on activities can be used for their own sake, or they can be introduced when the features of the particular activity used can be set in a meaningful context or extended to involve students in the content to be learned. Other factors have similar potential pitfalls and benefits. Games can be used to extend the use of mathematical ideas, and involve the students, or they can be used as an end in themselves. Bikner-Ahsbahs (2001) noted that mathematics games that are simple, and for which the aim is simply to win, do not allow for involvement in Mitchell's terms, and the competition so engendered is counter-productive to learning.

However, situational interest factors by themselves do not produce sustained interest in mathematics classrooms. While the catch facets produce interest in the short term, the development of interest and the learning benefits that can be expected to accrue from this interest requires these facets to be more frequently integrated with the curriculum (Mitchell, 1993). Just as games can be used either to simply catch interest or further developed to hold it, so can other facets of situational interest. For example, group work was reported to produce more interesting mathematics classes partly because teachers using groups were compelled to design lessons that emphasised deeper learning strategies rather than simple computational skills (Good, Mulryan, & McCaslin, 1992).

In arguing that interest-creating activities should do more than just create interest, or keep the class happy Zahorik (1996) suggests that it may be more effective to use intrinsically appealing content as a way of generating interest. Finding content ideas and facts that are interesting to students, and using these as either starters for lessons, or as an integral part of an inquiry-oriented activity, would retain the integrity of the content to be studied while using interest as a tool. In this way, mathematics can effectively be used as the context for developing mathematical ideas. Support for this view is given by Boaler (2002, p. 257) when she describes a teacher who "led her students in explorations of theoretical, abstract, and at times esoteric mathematical concepts that fascinated the children, causing her to conclude that [non-mathematical] contexts are far from necessary" for encouraging mathematics learning. The subject Mathematics may itself provide a context within which the use of what interests students may be more (or less) significant than in other subjects within our education system. If this context is indeed more significant then this strengthens the importance of research in this area. Zahorik (1996, p. 562) concludes: "It is reasonable to believe that teachers and teacher educators who wish to implement constructivist teaching must deal with the topic of interest and its relation to hands-on activities and content if constructivism is to become a classroom reality".

Many of the researchers involved in studying the relationship between interest and a focus on mathematical content have converging views. Mitchell (1993) suggests using meaningfulness and involvement to consolidate situational interest. These criteria logically imply the use of mathematical content for this purpose. The results of a study of 8^{th} grade mathematics students by Singh, Granville, and Dika (2002) reinforce the use of mathematical content for developing interest. Their findings confirmed that attitudes and interest positively affect achievement and suggest that specific strategies can be designed to increase interest, especially with "a curriculum that focuses on conceptualising and creating meaning and relevance" (p. 330).

In support of this view, Middleton and Spanias (1999) noted that students tended to be less anxious about mathematics learning if the teaching was facilitative rather than authoritarian and if understanding of mathematical concepts was stressed as being more important than rote learning. Perhaps that is because understanding ideas is a mental activity comparable to hands-on activities, and as such is inherently more interesting than learning facts for their own sake. Perhaps it is because in mathematics "students tend to internalize their experiences into self-concept more than in other subject areas" (Middleton & Spanias, 1999, p. 78).

The reality of what happens in many mathematics classrooms appears to be different from the facilitative ideal. School mathematics is often taught as a series of disjointed facts and procedures, which are meaningless in the lives of many students (Kaput, 1989; Weiss, 1990). In the course of his 1993 study, Mitchell saw little evidence of teachers successfully involving their students. This is backed up by evidence from the 1985/86 National Survey of Science and Mathematics Education in the USA, in which Weiss (1990) found that the further through the schooling process that teachers taught, the smaller was the proportion of teachers who indicated that finding ways to interest students in their mathematics learning was a priority. For example, 60% of teachers in the beginning mathematics classes had interest as an emphasis, compared with only 31% of the Grade 10-12 teachers.

Curriculum changes since these comments were made have attempted to address this issue (Ministry of Education, 1992). Mitchell (1993) also noted that involvement meant taking action to learn new things, and that this facet of situational interest has "a strong inverse relationship with lecturing" (p. 428). The lack of interest and high level of student passivity associated with teacher lecturing was also noted by Csikszentmihalyi and McCormack (1986). Even when teachers tried increasing student engagement with an introductory presentation statement or statement of orientation, Brophy and colleagues (1983) found that student engagement was higher when teachers went straight to the task to be done. They surmised that the cause of this might be because presentation statements are typically made when the task is difficult or boring, and the presentation statement merely signals this fact.

It appears as though little has changed since then. Boaler (2000) asked students about their experience in mathematics classrooms. She found that the three most dominant and recurring themes among students' perceptions were monotony, lack of meaning, and learning as an individual. Even more recently, Nardi and Steward (2003) found that some of the characteristics of secondary school mathematics classes were tedium, isolation, rote learning, elitism and depersonalisation. The narrower range of activities in mathematics classrooms compared to other curriculum areas (Stodolsky et al. 1991) may contribute to these feelings.

On the other hand, there is evidence that mathematics ideas can be alluring. Barnes (2001) describes what she calls 'magical moments', where students have that flash of understanding and intuition allied to certainty when solving problems that is always associated with feelings of excitement and pleasure. She describes the class in which she observed these magical moments as having atypical social norms for a mathematics classroom, that included the positive affect and persistence in a challenging task that are features of interest. She notes that "although a single event may not make a great difference to students' attitudes, the cumulative effect of many such moments has the potential to influence their dispositions to mathematics profoundly" (p. 41) and further suggests structuring mathematics classrooms in a way that cultivates magical moments. Ingredients that can be used to facilitate this restructuring are: use of open-ended challenging problems (at a suitable level), group work, the teacher asking questions rather than lecturing (compare this with the relation between lecturing and boredom noted by Mitchell, 1993), and development of social norms that encourage contributions, acknowledge the feelings of others, and focus on understanding.

2.8 Teachers' Views

Zahorik (1996) used a reflective writing approach with a group of 65 elementary and secondary school teachers from a variety of disciplines (including mathematics) who were his students doing a course on teaching using constructivist principles. The teachers, having teaching experience ranging from 1 to 19 years (with a mean of 6, standard deviation = 3.74), were asked for their ideas on what they did in the classroom to create interest. Teachers reported using the following actions to generate student interest, in order of decreasing frequency of use: hands-on activities, personalized content, student trust, group tasks, variety of materials, teacher enthusiasm, practical tasks, and variety of activities. A brief description clarifying the meaning of these terms follows. The brackets contain the percentage of Zahorik's subjects who reported using this action in their own classes.

- *Hands-on activities* (100%) refers to playing games, using blocks, participating in drama and the like, working on projects, and solving problems.
- *Personalized content* (65%) refers to teaching content or skills that are related to students' individual interests, either by relating the content to the student

interests, getting the students to generate the content, or by selecting content that is easily tied to student interests.

- *Student trust* (65%) activities are those that value student contributions and allowing students to make choices of their own.
- *Group tasks* (55%) refers to working cooperatively in pairs or larger groups.
- Using a *variety of materials* (29%) implies not just using many different common materials, but also using materials that are atypical in some way.
- *Teacher enthusiasm* (28%) includes aspects such as using humour, emphasising fun, taking part as a group member, using personal experiences as part of the teaching process, and showing excitement.
- *Practical tasks* (17%) are those tasks that have usefulness outside school, either because the end-product is useful, or because of the utility of the skills and knowledge gained in the activity.
- Using a *variety of activities* (11%), refers to variety in classroom tasks both within lessons and over time.

The most striking feature of Zahorik's study was that all teachers used hands-on activities in their classrooms to add interest, and nearly all teachers involved in the study thought that hands-on activities were important in triggering and holding student interest.

According to Csikszentmihalyi and McCormack (1986), enthusiastic teachers "are able to transform the usual drudgery of the classroom into an enjoyable experience" (p. 419). With respect to teacher enthusiasm the negative attitudes of prospective elementary teachers (Gellert, 2000) and the coherence of these attitudes (Stipek et al. 2001) are therefore of concern. Teacher enthusiasm was the most important reason for valuing the subject given by introductory psychology students studied by Covington (1999).

Teachers also avoided some actions in order to reduce boredom (Zahorik, 1996). Actions perceived as being harmful to interest, and hence avoided, were lecturing, explaining, directing, reviewing, testing, reading textbooks, doing workbooks, taking notes, using unsuitable tasks (too hard, easy, long, complicated, predictable, or artificial), student distrust, and teacher insipidity. Note that some of these are the duals of the actions taken to create interest (for example teacher insipidity and teacher enthusiasm; student distrust and student trust; artificial tasks and practical tasks). And even though the teachers did not say it directly, the dual of unsuitable tasks, that is using tasks that are suitable in terms of level and challenge, is implicitly a ninth action that teachers take for developing situational interest.

On deeper investigation Zahorik noticed that while the use of hands-on activities was pervasive, he estimated that at least 30% of the time its use was superfluous to what was to be learned, and in some cases it was an unnecessary obstruction to use of other more ecological situational interest factors. In a similar way, many of the prospective elementary teachers in Gellert's (2000) study used the activities to develop interest or fun as a way to mask the mathematics in the content they taught, reinforcing the message that many of them believed, that the mathematics was not interesting in itself.

The final reflective essay set by Zahorik (1996) in his study was entitled 'Subject-Matter Facts and Concepts I Have Found to Be Interesting to Students'. This topic arose out of the scarcity of actions reported taken by teachers to make use of the inherent interest in some content. One teacher said, "Facts, concepts, and ideas are generally not interesting in themselves. Either the students have to be interested, or the teacher has to creatively get them interested or structure activities to generate interest and make it meaningful" (p. 558). Teachers mentioned content topics that broadly fell into four overlapping classes: *human* (anything to do with people), *now* (topical), *nature* (referring to topics from the physical and biological world – compare this with Bergin's (1999) 'biophilia'), and *functional* (having practical use); and content ideas that were either *small* specific ideas or *big* broad generalisations. Secondary teachers in his sample were twice as likely to use content to stimulate interest as elementary teachers.

Zahorik (1996) concluded that generating situational interest is an important activity for teachers; the main method used for this was hands-on activities; and that teachers seldom use content ideas for this purpose. He noted that using the situational interest features referred to by teachers ran the risk of never getting to the learning required, and made a plea for using content to both interest and educate. "The trick in terms of interest is to find those concepts, generalizations, and facts that especially appeal to learners at various grade levels. Once these are identified, teachers can present them as statements at the beginning of lessons to catch attention immediately, embed them in a discovery activity, or use them in other ways" (pp. 561-562). He further observed that a long-term trend in education is to make it more pleasurable, and that the emphasis on hands-on activities appears to be a continuation of this trend. He conjectured that this pleasure could be increased while still focussing on content: "Perhaps the careful selection and use of interesting content ideas can increase students' pleasure and, ultimately, their learning" (p. 563).

The analysis above refers to the views of the sample of teachers in Zahorik's study about what they do to use interest based on what they think interests students. Caution should be taken when using teachers' observations of what they think students are thinking as these two sources of data often disagree (Givvin, Stipek, Salmon & MacGyvers, 2001; Nathan & Koedinger, 2000; Shkedi, 2001). Observers (in this case the teachers) often attribute more stable and less differentiated judgements than actors (in this case the students). This general effect, known as the actor-observer effect, was noted in a study by Givvin et al (2001) into student and teacher perceptions of student motivation could be a factor in the teachers' views and actions, and is one reason why students' views need to be considered carefully. One example of how teachers' views on what is interesting to students may differ from the students' views is with respect to the practical tasks suggested by the teachers in Zahorik's (1996) study. Teachers may be choosing tasks that appear practical to them, but these tasks may not be 'practical' for their students, and thus may be of only limited interest to students. In order for the task to be practical for the students, and hence generate interest, it needs to have *utility-goal relevance* Bergin (1999, p. 91). Furthermore, a practical task that engenders interest for one student because it is relevant to some individual goal that that student has may not be practical to other students.

2.9 Students' Views

Very little of the research that has been carried out on either situational interest or individual interest has been from the perspective of the students. What students find interesting in an educational context needs further clarifying. This is not a straightforward matter. As mentioned earlier in this literature review, the word interest in common English use has a variety of meanings to students. Even researchers differ in interpretation (Mitchell, 1993; Renninger, 2000). Renninger (2000) notes that middle school students often appeared to confuse individual interest with the triggering component of situational interest. The pleasure and fun related to activities rather than the persistent fascinated relational enquiry characterized by individual interest appears to be what students in middle school mean when they use the word interest. While this makes researching interest from a student perspective problematical it should not deter us from researching interest as it is important to students for developing positive affect (Schiefele & Csikszentmihalyi, 1995; Pollard, Triggs et al. 2000).

Most of the research about the role of interest in learning and development, both as an independent and as a dependent variable, has come from researchers performing experiments, or making observations on students and using correlational approaches. But the way students actually think and feel about tasks cannot always be inferred accurately from observation and experiment. Ruddick, May, and Wallace (1997) suggested seeking students' views in educational research. Further to that, Ruddick and Flutter (2000) claim that in listening to pupils' stories of their school experiences, teachers can gain clear and constructive insights and feedback.

Analysing students' views, via brainstorming and written reports on boring and interesting previous learning experiences, Small, Dodge, and Jiang (1996) suggested that extrovert attention-getting tactics and variety were the best strategies for increasing student interest and decreasing boredom. They also found that students believed teachers were responsible for making lessons interesting (or boring). This agrees with a study of mathematics classes in Germany, Japan, and the USA by Stigler and Hiebert (cited in Askell-Williams & Lawson, 2001) – at least for the American students in their sample. Many students think that the teacher has a great impact on the interest level of lessons (Lawson & Williams, 2001).

Self-reporting of students involved in further education by Athanasou (1998) correlated interest with 17 different cognitive, emotional, and value factors, and found that "the most important indicators of interest were ratings of effort, happiness, desire, familiarity, enthusiasm, importance, and enjoyment" (p. 223).

In an attempt to gain students' perceptions of features of interesting lessons, Askell-Williams and Lawson (2001) used a multivariate statistical analysis of middle school

(11 to 14 years old) student responses to 40 statements about interest in lessons. In their analysis both cluster analysis (CA) and multidimensional scaling (MDS) suggested three distinct clusters of student perceptions, which they described as *Teachers* (suggesting subclusters of *professional behaviour* and *personal qualities*); *Individual Learning* (suggesting *self-efficacy* and *individual achievement* as subclusters); and *Social Learning* (*social interaction, learning environment, collaborative activities, situational interest,* and *social learning*).

Further to this, the MDS suggested 2 dimensions, which Askell-Williams and Lawson interpreted as an *Individual-Social* continuum, and a *Student-Teacher* dimension. A very strong separation into the three clusters was noted using MDS, and the perceptual map (Askell-Williams & Lawson, 2001, p. 12) so generated unexpectedly showed that statements relating to self-efficacy were positioned very tightly on this map. As Askell-Williams and Lawson (2001, p.11) put it: "The nomination of self-efficacy items in the context of a study on interest suggests that the role of interest may deserve greater recognition as a factor that interacts with the development of self-efficacy and vice versa".

2.10 Summary

Middle school students arrive at mathematics classrooms with their own individual interests. These individual interests interact in a complex way with other variables (self-efficacy, ability, achievement motivation, and so on) to have a profound effect on learning, and vice versa. Middle school is a time when a general decline in intrinsic motivation in school takes place, and also when attitudes to many things, such as individual interests, tend to stabilise and remain with students for some time.

All students have individual interests (Tobias, 1995), some of which are aligned to work at school, and others that are not. Individual interests are associated positively with the quality of learning and academic achievement, but by their individual nature are difficult to harness in classrooms. Changing individual interests in order to make use of the academic benefits within classrooms is challenging.

On the other hand, situational interest factors can readily be used in classrooms to evoke interest, and this sometimes leads to individual interests developing. Externally exploitable techniques such as situational interest (and performance goals) may be among the most effective alternatives teachers have to support the development of individual interests by catching and holding interest. While a focus on situational interest, as opposed to individual interest, is relatively new, Hidi and Berndorff (1998) contend it is a "potentially powerful one in addressing the downward trend in academic motivation among individuals" (p. 74). The use of situational interest factors within the classroom, some of which will develop into enduring individual interests implies a significant change for mathematics teaching.

There is much that we don't know about this process. Among the many questions that remain to be answered are:

- What educational interventions evoke interest? What can teachers do to make classrooms interesting?
- What educational interventions maintain interest? How do teachers use these in classrooms?
- How does situational interest develop into individual interest? How can this process be used in classrooms?
- How do situational interest and individual interest interact?
- How much and in what ways do individual interest and situational interest influence learning?

The relationship between individual interest, situational interest, achievement, and other desirable educational variables is complex. Krapp (1999, p. 32) sums up the direction that these questions lead with the following comment:

> It seems clear that educational research should investigate how an individual interest develops, and under which conditions contents (or topics) offered in school can become an integrated part of a student's individual interest structure.

Chapter 3: Research Design

3.1 Introduction

The term educational research covers a wide field of endeavour, and takes on many different forms, even within the rather narrower field of mathematics education (Adda, 1998). The research process involves making decisions about, among other things, the research objectives, the data to be collected, the method(s) used to collect the data, exactly what data to record, how to interpret the data, and what form the response to the research objectives will take.

All of these decisions have a variety of possible valid responses. The validity of these responses is based on the decisions that have previously been made and the researcher's inquiry paradigm. This paradigm is the belief system or worldview that defines, for each researcher, the boundaries of what is legitimate inquiry. Such an inquiry paradigm is defined by the researcher's beliefs regarding the nature of reality (the ontological issue), the nature of the relationship between the researcher and what can be known (the epistemological issue), and how it is possible to find out about the abovementioned reality (the methodological issue) (Guba & Lincoln, 1994).

As the research process moves from the literature review to the research objectives to the research methodology and so on, decisions are made about how to proceed. At each point in the process, the decisions already made taken together with the researcher's inquiry paradigm inform the decisions yet to be made. Having now reviewed the literature and formed the research objectives, the next step is to decide on the research methodology.

As the main aim of this study was to explore the role of interest in learning Mathematics for Intermediate school children, the methodology needs to accommodate *describing* and *interpreting* whatever the data shows. This suggests using a qualitative methodology. Qualitative research is a generic term covering research that aims to "understand and explain the meaning of social phenomena with as little disruption of the natural setting as possible" (Merriam, 1998, p. 5). The main concern of qualitative research is finding out about a specific setting from the view of the participants, and honestly communicating these findings to others who may be interested. Arsenault and Anderson (1998) describe qualitative research as "a form of inquiry that explores phenomena in their natural settings and uses multi-methods to interpret, understand, explain and bring meaning to them" (p. 119). Merriam (1998) identifies five characteristics of qualitative research: understanding the phenomenon of interest from the participants' perspectives; using the researcher as the primary instrument for both data collection and analysis; fieldwork; employing an inductive research strategy; and producing a report that is richly descriptive.

Adopting a qualitative methodology does not preclude the use of methods that would often be described as quantitative (Patton, 1990). To do this would be to use a rather pure view of a qualitative paradigm that cannot be justified, as it is based on false dualities between facts and values on the one hand, and between qualitative and quantitative research on the other (Pring, 2000). Methodologies should not be prescribed by the epistemological paradigm used, but should be evaluated "by the epistemological standard of their fruitfulness *in use*" (Howe, 2003, p. 143). When choosing research methods Hiebert (1998) suggests that the choice of inquiry paradigm is of minor significance as the differences between the current paradigms are not unresolvable, and that the goal of research is "to clarify claims that we understand and to examine the warrants for these claims (ibid., p. 150). Other education researchers (Bell, 1993; Cohen & Manion, 1994; Linn, 1990; Patton, 1990; Silverman, 1993; Verma & Beard, 1981) suggest using a mixture of qualitative and quantitative techniques to promote the aims of qualitative research mentioned above.

Exploring the role of interest in learning Mathematics for Intermediate school children suggests understanding about such interest from the point of view of the students and teachers and developing a rich description of the use of interest in mathematics in Intermediate school. Therefore a qualitative methodology seems most appropriate, using mainly qualitative methods, although some quantitative techniques may be used where they support fulfilling the research objectives and are congruent with the qualitative aims of the research.

This chapter begins with a description of the data collection methods used, and the rationale behind the use of these methods. Central to this is the description of the researcher as the primary instrument for data collection and analysis. Next follows discussion about when and where the study took place, who the participants were, how decisions were made at each step in the process, and what actually happened. In this discussion details are given for the five stages of data collection, with data analysis described as an additional stage. The last section relates features of quality criteria such as ethics and the qualitative counterparts of validity and reliability.

3.2 Data Collection and Analysis

The data collection and analysis methods used in this study were mainly qualitative. Some quantitative analysis techniques were used (e.g. percentages, frequencies, and chi-square tests) to quantify aspects of the themes that emerged from the qualitative investigation. The instruments used for collecting data in this study needed to be sensitive to gathering data about the perceptions of both students and teachers regarding what students find interesting about learning mathematics at intermediate school. Several such instruments working together to act as one macro device were deemed useful for this purpose. These were applied to both students and teachers alike, and were focus group discussions, questionnaires, interviews, journals and the researcher.

Focus Group Discussions

A focus group is a specific technique for holding a group discussion. It is more than just a group discussion. The purpose of a focus group is to concentrate on particular topics related to the research objectives. The researcher, who has control over the topics that are discussed, and also the order of these topics, determines the structure of a focus group. Members of a focus group are usually similar to each other in some way (Crowl, 1996). In this study, each focus group consisted of volunteers who were members of the same mathematics class.

In this study focus groups were used to prepare for the rest of the project, using the rationale stated by Anderson (1998): "They [focus groups] are particularly useful in helping develop specific research questions and issues for further exploration" (p. 201). Thus, the main purpose of the focus groups was to discover general areas or themes related to interest in mathematics classrooms for the purposes of further examination during the questionnaires, interviews, and journals.

The focus groups also enabled the researcher to meet with all the student participants and establish some rapport with students who had volunteered for the study. This meant that all students were able to feel part of the study prior to filling in the questionnaire. Furthermore, the focus groups gave the researcher an opportunity to distribute the booklets in which the participants were to write their journals, and to give an explanation of what was required in these journals.

Focus group discussions have advantages over other qualitative instruments. They are efficient in terms of time and money, and the group dynamics allow participants to be prompted to contribute by others in the group. There is time for clarification of questions, which further improves the group discussion, and topics selected by the researcher can be discussed openly using the natural language of the group members (Fontana & Frey, 1994).

Furthermore, because focus groups enable the researcher "to capture a richer interpretation of participant's perspectives" (Janesick, 1994, p. 211) than might otherwise be possible and to "observe interactions among participants" (ibid.), they can provide a useful form of triangulation (Fontana & Frey, 1994). Bouma (1996) summed up many of the advantages of focus groups for this study when he said:

> The focus group allows the researcher not only to identify issues and attitudes but also to see how various people from the group respond to the positions taken by others. (p. 179)

All but one of the focus groups in this project consisted of between seven and ten members—well within the bounds suggested by the research texts (e.g. Crowl, 1996; Polit, Beck, & Hungler, 2001). The one exception was a group of 16 who were all members of the Year 8 top stream class. The group was large due to the difficult logistics of the researcher arranging meetings with this particular group. The researcher was sensitive to the suggestion that for groups whose members "interact with one another on a regular basis, their responses may not be completely candid" (Crowl, 1996, p. 237), and that this may have been more obvious in a comparatively large group.

Questionnaires

The purpose of a questionnaire is to gain access to what a subject thinks, feels, believes, has experienced and remembers in relation to a specific topic. It is a highly structured instrument, in that each subject responds to exactly the same set of questions and statements, although each subject may have unique interpretations. The questionnaire aims to measure what the respondents think, but actually records what they say in written form. The written responses are based on the subjects' own interpretations of what is written in the questionnaire, their honesty and self-knowledge regarding the questionnaire statements, their ability to articulate their beliefs, and how these responses are finally interpreted by the researcher.

Particular advantages of questionnaires include ease of administration to large groups in a short space of time; standardisation, to the extent that all subjects receive the same questionnaire, and for most subjects the relationship between researcher and subject is not problematic; and subjects are able to complete a questionnaire in their own time.

Interviews

An interview is a specific way of communicating. It is a one to one discussion between the researcher and the interviewee, wherein the researcher attempts to find out and clarify information about the views and ideas that the interviewee holds with respect to the research objectives (Cohen & Manion, 1994; Merriam, 1998). Interviews differ from many other forms of qualitative measurement in that human contact is central to the process. In the case of the face-to-face interviews conducted in this study, this contact is characterised by body language transfer as well as oral communication regarding issues pertinent to the research objectives.

Interviewing is a very effective way of collecting qualitative data – "sometimes the only way" (Merriam, 1998), and has definite advantages over other forms of qualitative data collection. Additional to the body language mentioned above, questions asked during an interview can be clarified until the respondent knows exactly what is being asked and until the researcher is sure that this is the case. The ability to delve deeper when required means that interviewing is a good means of realising rich data sets about a narrow range of topics, and where the sample is necessarily small (Burns, 2000), as was the case with the teachers in this study.

Interviews also have disadvantages. In comparison to questionnaires, they take longer to conduct, data collecting is more time-consuming and more problematic (electronic recording equipment can fail), and hence are often more resource intensive. The presence of an interviewer allows the possibility of biases to creep into the data based on the participant's response to the interviewer, rather than the interview itself (Polit, Beck, & Hungler, 2001) or similar subjectivity on the part of the interviewer (Cohen & Manion, 1994). The researcher in this study aimed to ensure that all interviewees were comfortable during the interview, in order to minimise this bias. All interview times for this study were negotiated openly with students and teachers, and the researcher made a conscious effort to ensure that interview times were within the control of the participants.

Structured interviews involve the use of a fixed set of questions or statements to which all subjects respond. When questions are of the fixed-response type the structured interview is essentially a questionnaire that is delivered orally. Advantages of the structured interview over a questionnaire are i) that the subject's reading and writing comprehension are removed as possible communication blocks, and ii) that body language and other forms of verbal expression are accessible to the researcher.

An *unstructured* interview differs from a structured interview in that the researcher-interviewer has a conversation with the subject about topics relevant to the research objectives. This framework allows the subject scope to discuss in an open way all aspects he or she considers pertinent to their ideas related to any prompts that the researcher uses as part of their general interview plan. This has the advantage of being able to provide data that is rich and personal. Disadvantages include the increased amount of judgement that the interviewer needs to use in directing the interview, and in analysing the data. Such an increase means that there is a greater possibility of an interviewer effect in the data collection and analysis.

The structured-unstructured issue is raised here because the *semi-structured* interview (Burns, 2000; Crowl, 1996; Polit, Beck, & Hungler, 2001) method was used in this research. This form of data collection is a compromise between the two extremes mentioned above. Using this approach the structure of the interview and the interview topics are planned before each interview using an interview guide. The guide offers flexibility of expression and question order during the interview (Burns, 2000). Questions are viewed as starters to further comments, and issues that arise in relation to the planned components during the interview can be investigated immediately.

Using the semi-structured interviews in this study enabled both student and teacher questionnaire and interview responses to be clarified and expanded. This allowed collection of data related to attitudes, values, and emotions of the respondents, in language natural to them (Burns, 2000). It also gave the student and teacher volunteers a chance to reflect on what they had said in the questionnaire, and further develop their own ideas with respect to the research objectives.

Journals

A journal or diary is a record of daily events kept over a specific time period. As there is no need for an observer or interviewer to be present, journals appear to be attractive as an efficient way to gather data (Bell, 1993; Burns, 2000; Hodder, 1994). However, the large amount of useful data possible to be gained from journals can make data analysis problematic unless the same amount of care that is taken with wording in questionnaires and interviews is also taken with using and analysing journals (Bell, 1993). Journals are particularly effective for "process" questions, which record experience over time or change and may have stages and phases (Morse, 1994); when the information provided in the journal may be different to data available in any other form (Hodder, 1994) and for describing facts and activities over a set period of time (Bell, 1993; Burns, 2000).

The journal entries in this project were aimed at finding out about students' thoughts in relation to interest in mathematics classrooms covering a time span of between 4 and 6 weeks (depending on the timing of the focus groups). Caution was taken from the warnings from Bell (1993) and Burns (2000) to make sure that the participants were clear as to what was required, that they were at an appropriate educational level for this process, and to be aware that subjects may modify their behaviour over the journal-writing time in line with what they thought the researcher may want.

The Researcher

In qualitative research the researcher is the central component of the research process. Furthermore, "because the primary instrument in qualitative research is human, all observations and analyses are filtered through that human being's worldview, values and perspective" (Merriam, 1998, p. 22). The researcher chooses the area to be studied, the setting, the research design, the variables to be measured, and the instruments used for measuring these variables; collects the data; makes any adaptations to either the process and/or the data gathering devices that are necessary (in the researcher's opinion) to reach the research objectives; and analyses the data – developing themes and highlighting particular items from the data. The interdependent nature of "observational and conceptual contents" (Howe, 2003; p. 2) means that the researcher's perspective influences both form and content throughout the study (Arsenault & Anderson, 1998; Ernest, 1998). The end result of a qualitative study by a single researcher is the researcher's reality. This is just one of the multiple valid realities possible.

As a consequence of the ubiquitous role of the researcher in qualitative research it is essential to probe the beliefs and credentials of the researcher to establish researcher credibility (Polit, Beck, & Hunger, 2001), and to allow the reader to establish the contribution of the researcher (Smith, 1996). In order to do this the standpoints and relevant credentials of the researcher ought to be openly stated (Creswell, 1994).

The researcher is a teacher with thirty years teaching experience in teaching Mathematics, Statistics, and Computing, in the New Zealand secondary and tertiary sectors. The researcher is presently teaching predominantly Statistics to a range of tertiary students, from certificate level to degree level. While the researcher is an experienced teacher, he is a novice researcher. The present study was chosen because the researcher is fascinated by mathematical ideas, wondered how that fascination could be imparted to students in schools, and had a daughter in Year 7 at the time of the data gathering.

Due to the researcher's involvement with mathematics education, he holds several assumptions upon which the research study stands. These assumptions need to be clear to those reading the study, and are:

(i) that all students are capable of learning useful mathematics skills and ideas. The term 'useful' is used to indicate that these skills and ideas are used, either explicitly or implicitly, in the everyday life of the students;

(ii) that there is a positive link between interest and the amount of useful learning that takes place;

(iii) that there is a positive link between interest and classroom behaviour;

(iv) that interest can be established, fostered and enhanced by classroom events;

(v) that an individual's interests change and develop over time;

(vi) that Years 7 and 8 are significant years in establishing lifelong areas of interest;

(vii) that mathematics teaching should aim to develop relational understanding (Skemp, 1987); and

(viii) that most people enjoy learning.

3.3 The study: Where, Who, When and How

Where the study was set and who was in the sample

The study was carried out in a large state intermediate school. The school, a decile eight school, is one of four state intermediate schools in the city. Mathematics was streamed in this school, separately for both Years 7 and 8. Five teachers volunteered to participate in the project. As one teacher taught two mathematics classes (the top streams in Years 7 and 8), this meant that six classes (three each of year group) were canvassed for student volunteers to participate in the study. One hundred and two students volunteered to participate in the study but one student volunteer left the school before the study commenced. The breakdown of the remaining 101 students by level, gender and Year is shown in Table 3.1. Students in the study were mainly 11, 12 and 13 years old.

Table 3.1 Composition of student sample by Year, gender and stream

	Top stream classes				Other than top stream classes		
	Boys	Girls	Total		Boys	Girls	Total
Year 7	10	12	22	Year 7	16	24	40
Year 8	12	4	16	Year 8	7	16	23
Total	22	16	38	Total	23	40	63

When and how the study proceeded

There were five stages to collecting the data for this study. These were completed over a period of 11 months, from February until December.

Stage One: Getting started and finding the participants

Initially discussions were held with teachers and the Principal of the school at which the study was conducted in order to establish that the study was feasible with respect to staff and student participation. The Principal invited the researcher to give a short talk at a regular school staff meeting (in July) to describe the proposed study and the level of commitment required by staff who volunteered. At this meeting an information sheet about the project was given to all interested teachers (Appendix 1), along with a consent form. Five teachers subsequently volunteered to take part in the study.

Each of the participating teachers then gave the students in their classes an information sheet for themselves and their parents/guardians (Appendix 2) and consent forms for both student and adult. One hundred and two students from six classes returned the consent forms.

Stage Two: Facilitating the focus groups

Separate staff and student focus group discussions were held. The teacher focus group discussion itself took about 45 minutes, with a little more time devoted to the "cookies and coffee" suggested by Morse (1994, p. 229) "to facilitate focus groups". The central purpose of the teacher focus group was to use the synergy of the group to begin to develop a rich description of teacher attitudes and feelings about using interest in teaching mathematics (Anderson, 1998). These beginnings were used for further exploration in the questionnaires, interviews, and journals. The teacher focus group questions and topics for discussion presented in Appendix 4.

The student focus groups were held in the students' usual mathematics teaching times, by arrangement with their mathematics teacher. Hence the groups consisted of students from the same mathematics class (but from different home rooms due to the streaming operating in the school). Ninety-nine of the 101 student participants attended one of the focus group interviews. Due to class organisational arrangements focus groups varied in size from 7 to 11 students, with one of 16. The researcher directed and recorded the focus groups, which took between 15 and 20 minutes, using the discussion questions/topics found in Appendix 3. The focus group discussions were recorded on audiotape, and the researcher also made written notes. These notes were used to clarify some of the students' comments that were initially hard to decipher from the audiotape.

The focus group data was analysed separately for both teachers and students. Themes sifted from the raw data were compared with previous research looking at the use of interest in classrooms. The student and teacher questionnaires were designed from a synthesis of focus group data and previous classroom research (Appendices 5 and 6 respectively).

Stage Three: Keeping the journals

In order to get another view of what interests students in mathematics classrooms all students participating in the study were given a notebook and asked to keep a journal of their thoughts and reactions relating to interest (or boredom) in their mathematics classes. Students began the journal-keeping process immediately after their focus group discussion (in early to mid August) and the journals were collected at the end of term (late September). Students were asked to take a few minutes at the end of each mathematics lesson to write any comments they had relating to how interesting (or not) they had found the lesson, what there was about the lesson that caused their reaction, and especially if there were any specific mathematical *ideas* that they found interesting.

This Stage of the project would have been improved with better monitoring and direction of the staff and student participants. At the time of the focus group interviews all students were given a notebook in which to maintain their journals. Journals were only received from 59 of the 102 students, and 4 of the 5 teachers. Table 3.2 provides a breakdown of the demographics of students who returned their journals. The numbers in brackets show the number of participants in each category.

Table 3.2 Students who returned journals by Year, gender and stream

	Top Stream Classes				Other than top stream classes		
	Boys	Girls	Total		Boys	Girls	Total
Year 7	7 (10)	8 (12)	15 (22)	Year 7	8 (16)	15 (24)	23 (40)
Year 8	7 (12)	3 (4)	10 (16)	Year 8	4 (7)	7 (16)	11 (23)
Total	22	16	38	Total	23	40	63

Despite the fact that some of the student journals offered no comments on the interest or lack of it in the mathematics lessons, the journals were valuable in that they gave a perspective that differed to that gained from the other sources, in that it referred to specific daily occurrences.

Stage Four: Completing the questionnaires

All participants in both groups, students and teachers, were given a questionnaire in October. The questionnaires were not anonymous. One reason for this was that these were to be used for prompting and clarification of responses during the interviews for selected students. Ninety-six of the 101 students completed the questionnaire—the others were absent at that time.

Stage Five: Conducting the interviews

All five teachers as well as seven selected students were interviewed individually. The purpose of the interview was to clarify and expand issues that arose in the questionnaire. Students were selected randomly until a range of factors – gender, Year level, stream – were covered by the group of interviewees. Table 3.3 shows characteristics of the interviewees. The student interviews lasted 15 minutes on average, while the teacher interviews averaged 30 minutes in length. The interviews were conducted near the end of the academic year.

Table 3.3 Interviewees by Year, gender and stream

Students

Gender	*Year*	*Stream*
Female	8	Mid
Female	8	Top
Female	7	Mid
Female	7	Mid
Female	7	Top
Male	8	Low
Male	8	Top

Teachers

Gender	*Year taught*	*Stream taught*
Female	8	Low
Female	8	Mid
Female	7	Mid
Male	7	Mid
Male	7 & 8	Top

Stage Six: Analysing the data

The first round of data analysis included the focus group data from the teachers, then the students. Themes within the teacher data were compared with those from the student data. Following this analysis a questionnaire was designed to produce a rich description of interest in learning mathematics.

This questionnaire had a number of questions that used a Likert scale (Burns, 2000), and others that were open-ended. The attitude statements on the Likert scale went from "really interesting" which was scored as 1 through to "really boring" scoring 5. In order to see patterns over the whole group, and also by gender and stream, some descriptive statistics were calculated for these scores. A chi-square analysis was used to compare the pattern of responses by gender. As this is an observational study and not an experiment, the term 'significant' when used in this thesis is used in a specific way. It is not used to imply generalization to another bigger population. It simply expresses the idea that the two groups compared had quite different patterns of responses.

3.4 Quality Criteria

Research projects need to exhibit evidence of reliability and validity (Burns, 2000; Creswell, 1994; Merriam, 1998). These notions are couched in terms of the positivist paradigm (Denzin & Lincoln, 1994), and are often stated in different terminology for other qualitative paradigms (Creswell, 1994). Nevertheless, critically assessing the relevant versions of these issues is an essential quality aspect of a qualitative research project, "even if one takes a more interpretive stance" (Huberman & Miles, 1994, p. 439).

Reliability refers to whether or not the research project is dependable and in quantitative studies it is often measured by the extent to which results produced by one study can be reproduced by another equivalent study (Burns, 2000; Merriam, 1998). **Validity** on the other hand is the extent to which the data, results, conclusions and interpretations of a project are actually correct in reality. There are two sides to this concept. *Internal validity* relates to how accurate the data collection instruments and interpretations are in measuring and portraying the true situation of the participants relative to the research objectives. This can be affected by the truthfulness, awareness and comprehension skills of the participants, the clarity of the data collection instruments used, and the observation and other skills of the researcher. *External validity* on the other hand relates to how generalisable the project results are to other groups (Anderson, 1998). The strength of qualitative research is that it is context-based, and this increases validity albeit with consequent risks to reliability that need to be countered by the study methodology (Henwood, 1996).

Internal validity

The internal validity (or credibility or trustworthiness (Guba & Lincoln, 1994)) of this project can be judged by its structure. There is evidence to underpin this quality measure in the openness of the study. By presenting the research design results and conclusions openly, and moreover declaring the rationale for decisions made during the project, as well as describing the researcher carefully, readers are able to judge the credibility of all phases of the project, from data collection to conclusions.

One specific way in which this project increases internal validity is by using triangulation between methods (Anderson, 1998). Using a variety of instruments, as was the case in this study, may produce convergence, may allow complementary aspects to surface, may be used developmentally (where one method is used in series with another), may provide contradictions that aid the development of a more complete response, and may also provide breadth (Greene, Caracelli, & Graham, cited in

Creswell, 1994). The use of triangulation in this study was partly developmental (the focus groups were used for the development of the questionnaires, which in turn were used for the interviews), and did indeed produce all the abovementioned factors to varying extents. This enabled a broader, more complete and denser response to achieving the research objectives.

External validity

External validity (or transferability (Guba & Lincoln, 1994)) is about how generalisable the study results and conclusions are to other situations. The idea of generalizability derives initially from quantitative positivist paradigms, and is not the main point of qualitative studies (Bell, 1993). Rather, qualitative studies focus on forming "a unique interpretation of events" (Creswell, 1994; p. 159). Whatever the prime focus, some ability to generalise appeals as being a useful adjunct to the prime research focus. In response to this Creswell (1994) suggests that qualitative studies discuss a "limited generalizability" (ibid., p. 159).

External validity or generalizability in the form of finding universal laws is not possible, nor even desirable, with qualitative research. Notwithstanding this, it may still be possible and useful to generalise in certain contexts, depending on the fit between the research study and the situations to which generalisation is desired, provided the study contains rich descriptions (Schofield, 1993).

The students and teachers in this study existed in a particular time and place. The particular results and conclusions are described with hindsight. Readers are in the best position to confer or refute any limited generalizability for groups with whom they are involved.

Reliability

Reliability (or dependability (Guba & Lincoln, 1994)) relates to how repeatable are the results and conclusions of a study. For qualitative studies reliability cannot be measured. What is important is whether or not the thick description that is the result of a particular study is dependable. "Qualitative research depends on the presentation of solid descriptive data, so that the researcher leads the reader to an understand[ing] of the meaning of the experience under study" (Janesick, 1994, p. 215).

In order to meet the reliability or dependability criterion in a qualitative study, Creswell (1994) suggests that fully describing the central assumptions and the decision-making throughout the project, and openly stating the limitations and biases that may be present increases the chances of replication in similar settings. In addition Merriam (1998) suggests that the use of triangulation increases reliability, "especially when using multiple methods of data collection and analysis" (p.207).

Besides the use of multiple methods of inquiry, the reliability or dependability of this study can also be estimated by how closely its results and conclusions fit with other similar research. The considerable overlap between the results of this project and existing research literature (e.g. Zahorik, 1996), albeit that the projects have different foci, reinforces the reliability of each project. Notwithstanding the comments about reliability above, this qualitative study is unique. This means that replication will neither be possible nor relevant. The researcher has attempted to understand and describe the actual experience of the students and teachers in this particular project, and place this in the context of other research on interest.

Ethics

Qualitative studies in education usually deal with human subjects, and are thus likely to involve ethical issues. The researcher has the responsibility of making sure that the rights of all participants in the study are preserved. These subjects need to be protected from harm, not have their time wasted, and be treated sensitively. Bouma (1996) sums up the issues for qualitative researchers when he says:

> For social scientists the major ethical issues centre around gaining an appropriate form of informed consent, respecting individual privacy and confidentiality, being aware of the power dimension of the relationship between the researcher and the subject of research, and ensuring that the research procedures (variables selected, measurement used, sample selected, and design employed) are adequate to answer the questions being asked. (p. 197)

This research project complied with the ethical standards of the "Code of Ethical Conduct for Teaching and Research Involving Human Subjects" (Massey University, 2000) .

(1) Approval was sought from and granted by the Massey University Human Ethics Committee.
(2) Approval was sought from and granted by the principal of the intermediate school to conduct the study at the school.
(3) Participants were informed of the researcher's credentials and reason for doing the study.
(4) Informed written consent was obtained from all participants.
(5) The questionnaires, journals and interviews were handled in a way that ensured the confidentiality of participants. Holding focus group discussions meant that participants within each focus group were aware of the contributions of others in their group. Confidentiality of material from the focus groups used in the thesis is ensured by not attributing contributions by the names or particulars of the participants.

3.5 Summary

A qualitative approach with some quantitative aspects was employed in this research project, which investigated what makes mathematics interesting in intermediate (middle) school classrooms. The researcher as the primary instrument in this study used four other data collection methods: focus group discussions, journals, questionnaires and interviews. Data was collected from 5 teachers and 101 of their students at a single intermediate school, and the results are presented in Chapters 4 and 5.

Chapter 4: Student Interests

4.1 Introduction

This chapter presents the results of what the students said about interest in learning mathematics. The four data-gathering instruments that were used worked together to develop a rich description of what interests students in learning mathematics at school, what they would like teachers to do to create, develop and maintain this interest, and how important such interest is to students regarding learning mathematics at intermediate school. While all of these data gathering devices were used as one macro device, each of the parts tended to emphasise different aspects of interest in the mathematics classroom.

The data that is used to present these student results has been coded in the following way. An identification number between 1 and 102 identifies students. This number is preceded by an 's' for student. The gender (male or female), year at school (7 or 8), and data instrument (focus group (FG), questionnaire (Q), journal (J) or interview (I)) are also identified in the following way: [s45:f8:J] after a quote represents data that has come from the journal of a female, year 8 student. The researcher was not often able to identify the individual at the source of comments in the focus group discussions, so that quotes from focus groups are usually left un-sourced. Some of the students refer to specific teachers, who will be referred to as T_A, T_B, T_C, T_D and T_E.

Students generally believed that being interested in learning mathematics was important, for a variety of reasons. These reasons are discussed in the following section. Themes that emerged for the factors that made mathematics interesting to students in mathematics classes at intermediate school are then developed in Section 4.3, followed by an investigation into what students find dull or boring about learning mathematics in intermediate school classrooms. Finally in this chapter, student suggestions for teachers regarding how to make learning mathematics more interesting are explored.

4.2 The Importance of Student Interest in Learning Mathematics

In the questionnaire students were asked, "How important to you is it that teachers try to make learning Mathematics more interesting?" Students were overwhelmingly of the opinion that it was important to them for teachers to make mathematics interesting. Forty-five percent of students thought that this was *very* important, and another 38% thought it was quite important. It was admittedly a leading question, asked of students volunteers in a study about interest in learning mathematics. Even so, the responses were illuminating as many students added a rationale for their view.

The most common reason offered for the importance of making learning mathematics interesting was that otherwise it would be boring. Comments to this effect included:

- *Very important because maths is boring. [s3:f7:Q]*
- *Very important otherwise it's no fun at all. [s53:m7:Q]*
- *Very important it seems that most teachers try to make maths as dumb as possible!!! [s84:m8:Q]*

One student argued that teachers also ought to be interested in mathematics (assuming that the "they" in the quote below refers to the teacher rather than the students).

> *Very important because if they are not interested you will not learn much. [s86;m8:Q]*

Other popular reasons for interest in mathematics learning being important were variations on the theme that interest was linked to learning. These students argued that they learned more, or more easily, when they were interested, or conversely learned less when they were not interested or bored. For example:

- *Quite important because if it is more interesting it's easier to learn something new. [s95;f8]*
- *I think people learn more when it's interesting, so it's better when it's fun. [s60;f7]*
- *Very important because you do not want to learn if work is boring. [s56;f7]*
- *When stuff is more interesting people think harder about that topic, so I think it's important. [s32:f7]*

Some students related their lack of learning when work was not interesting to lack of effort caused by boredom.

- *Mostly if Maths isn't interesting I don't try my hardest. [s46:m7]*
- *If it's boring then I will just switch off and not learn. [s2:f7]*

This lack of learning caused by disinterest was taken a step further by some who noted that their future job prospects may be diminished, or that they may lack skills that depend on mathematics at a later stage.

> *Very important because if it isn't interesting you don't feel like doing any maths and you don't learn anything and you have to because you will probably need maths when you grow up. [s94;f8]*

One student clearly expressed the view that their teacher was both responsible for making mathematics interesting and also ensuring their future success in life!

> *Because it could be one of their faults that I could become a bum. That's their job and they chose to be a teacher. [s6:f7]*

Another group of reasons given for wanting mathematics to be interesting in the classroom related to affective considerations. Students considered that they would have a bad attitude to mathematics and not enjoy it, or would dread going to mathematics classes if it were not interesting. Conversely, others thought that being interested in mathematics improved the chances of enjoying learning.

- *It is important a lot because I don't want to come to school dreading that I have maths. [s82:f8]*
- *Pretty important because when maths is not interesting it's boring. [s80:m8]*
- *I think that it is quite important because if maths is fun and interesting kids will enjoy learning. [s10:f7]*

One student thought that if mathematics was interesting the students would be better behaved.

> *Well if a teacher does really boring stuff then the children begin to think that maths is really boring and start to not cooperate. [s38:m7]*

Of the 18% (n = 17) of students who felt that it was not important to make mathematics interesting, a variety of reasons were supplied. Some felt that they would still feel negative about mathematics even if it were interesting: "Not very important because I don't like maths anyway" [s14:f7]; whereas others felt positive about mathematics whether or not teachers tried to make it interesting: "Not really important because most maths is interesting anyway" [s91:m8].

However, even for the students who did not think making mathematics interesting was important there did appear to be a connection with behaviour management that may make interest relevant in a secondary role.

- *It's not really that important. Unless they are always talking. [s9:f7]*
- *I don't mind if they're not interesting as long as it is clear enough to know what to do. [s12:m7]*

Such comments as these suggest at least limited support for mathematics being better for students when classes are interesting (or at least not boring), even from students who thought it was unimportant for mathematics to be made interesting.

4.3 What Makes Mathematics Interesting to Students

The results of the analysis of the data collected from focus groups, questionnaires, interviews and journals regarding what students find interesting in mathematics classrooms are organised into five areas. Section 4.3.1 discusses ***activities*** that students found interesting in their mathematics classes. The interest component in using ***group work*** for learning mathematics is developed in section 4.3.2. Section 4.3.3 focuses on aspects of ***interesting mathematical content***. Section 4.3.4 looks at ***classroom variables***, including teacher qualities, that develop and maintain interest in learning mathematics. The final section in what makes mathematics interesting to students investigates the connections between interest and ***positive affect***. These areas are not mutually exclusive, as it is possible for example to have a classroom exercise that is active, involves group work, and uses interesting content. In the discussion that follows evidence of interest may come from data where there was more than one interest factor present. Determining the level of interest for any one of these interest factors is problematic, as this level may be confounded by possible interaction between factors.

Several questions in the student questionnaire asked students to rate the interest level for a variety of types of activities that were noted in the earlier research studies, e.g. hands-on activities, group work. A Likert scale with five levels was used for these ratings. The student responses were scored as *very interesting = 1*, *interesting = 2*, *neutral = 3*, *boring = 4*, and *very boring = 5*. Response means for the activities ranged from 1.8 to 2.7 indicating positive interest in all of the suggested classes of activities. The results are summarised in Table 4.1.

Table 4.1: Student Responses to Interest in Classes of Activity

Class of Activity / *Response*	Really interesting	Interesting	Neutral	Boring	Really boring	No response	Median	Mean	Standard deviation
Group work	36	44	11	2	2	1	2	1.8	0.9
Hands-on activities	24	58	11	3	0	0	2	1.9	0.7
Enthusiastic Teacher	38	39	15	2	2	0	2	1.9	0.9
Related to Own Knowledge	26	37	26	5	2	0	2	2.2	1.0
Variety of Activities	13	48	31	3	1	0	2	2.3	0.8
Practical Tasks	15	47	28	4	1	1	2	2.3	0.8
Student Trust	9	52	25	6	2	2	2	2.4	0.8
New Activities	11	37	38	5	5	0	2	2.5	1.0
Challenge	12	35	27	16	6	0	3	2.7	1.1
Easy Mathematics	13	18	33	17	15	0	3	3.0	1.2

A statistical analysis using chi-square was carried out to compare the response patterns of the boys and the girls. As this was an observational study using volunteer participants, and not an experiment, significant differences wherever they are claimed are between the groups of study participants, and are not claimed between the populations of boys and girls from which they were taken.

4.3.1 Activities

Students in this study found mathematics more interesting when they were actively involved, and this usually meant doing something physical. They rated hands-on activities among the most interesting classroom activities (mean = 1.9). Hands-on activities also had the least variable rating (standard deviation = 0.7) with the responses virtually all *very interesting* and *interesting*. Only 3 of the 96 students who answered the questionnaire thought that hands-on activities were boring. Even though the girls predominantly answered *interesting*, and the boys' percentage of *very interesting*s was nearly twice as great as for the girls, there was no significant difference in the patterns of results for boys and girls.

The student focus groups suggested several distinct subsets of hands-on activities were influential in catching and/or holding interest in mathematics lessons. Comments in the questionnaires, interviews and journals suggested further divisions. The categorisation below goes further than either of the categorisations discussed by Bergin and Zahorik. The interest-producing subsets, in order of frequency mentioned in the focus groups, were: simply *moving* around (sometimes outside the classroom); *games* (including games on the computer); *competition* (sometimes associated with games – but not always); using *manipulatives* (including those who said simply 'hands-on'); *drawing and making* (activities that appealed to the aesthetics and/or visual creativity); using *food*; and *problem solving*.

Moving around involved physical activities and physical relocation. Specific activities included "walking around a marked hectare", "drawing big circles on concrete", "measuring outside", "finding volume using water", "went to Library for research", "surveying other classrooms", "skip for a minute; test pulse before and after", "acting things out" and "setting up the athletics track".

Many of these activities were outside the classroom, which may have been an additional interesting ingredient. Several students suggested that teachers could "let us go outside and learn outside" to make mathematics more interesting or noted that those activities that took place outside the classroom were fun.

- *Measured out circles using radius. Fun because we went outside. [s36:m7:J]*
- *Drawing circles of 20m and 40m. It was really fun because we did it outside and it was hands-on. [s48:f7:J]*

Another justification offered in relation to physical activities was the likelihood that such activity would more likely involve tasks related to 'real' life.

> *We walked around the school perimeter and we had to tell the temperature of the grass and we had to estimate and then find the actual one to see how far we were off. Just to get out and use all the things that you would in real life. You can sit there and learn about how they work, but if you actually use them then it's more interesting. [s2:f7:I]*

The next most commonly mentioned hands-on activities in the focus groups were ***games***, including games on the computer. Specific games that were mentioned were the 24 game, Maths Circus (a computer game with several levels of problem solving tasks), Maths Bingo, and Buzz. Other games mentioned during the remaining phases of the study were the transformation game, fraction wheels, Weakest Link, 3 Amigos, and the decimal version of the 24 game.

- *Today we also played games as a treat and I played the transformation game and fraction wheels. It was easy. [s96:f8:J]*
- *Today we did Maths Circus on the computer and it was really fun. [s3:f7:J]*

Many of the students stated a proviso about games—they should be "Mathematics games" or they should be played "while learning". The students were not interested in just playing games gratuitously—they wanted a mathematical learning purpose to any games they played.

> *When you play games but still learn it's a fun way of learning. [s88:f8:Q]*

For some students the interest in games appeared to override lack of comprehension.

> *Today was ok, we done all games it was fun. I didn't understand a lot of the games though. [s96:f8:J]*

The suggestion to play games in mathematics lessons to make mathematics classes more interesting was pervasive throughout the study. Students used virtually any question or prompt to make a plug for playing more games in mathematics classes.

The use of ***competition*** as a situational interest factor was often associated with winning—but not always. One student noted that he found competitions interesting "when you win", but another commented:

> *I like to compete with other people to see if I can beat them. ... I don't totally care if I don't win as long as I did well ... and I'm a good loser. [s67:m8:I]*

Many students enjoyed a competitive aspect to work in the mathematics classroom. There were a variety of ways in which competition was implemented, from having boys versus girls mathematics fact races, to playing the 24 game in a knockout competition, to having an in-class Mathletics competition. Competitions where there were house points[5] at stake were very popular. Teachers were able to award house points for various aspects of 'good' behaviour – and learning in class time was sometimes one such aspect that was used for awarding house points. There was also an inter-house speed-at-tables competition in which all classes took part.

- *It was cool. Different. [s36:m7:J]*
- *Times tables test. Inter-house tables test. Fun and competitive. [s39:f7:J]*

For some students having a group aspect to competition appealed.

> *Times tables competition in little groups. Didn't have to just do the tables by yourself. More fun. [s31:f7:I]*

One specific aspect of interest in mathematics competitions was involvement in outside mathematics competitions. There were three possibilities for this type of experience for students in this school. One was Mathletics, an inter-school competition with a team section, an individual section, and a problem solving section. The inter-school version of this competition was preceded by an in-school version for the purpose of including all students, and as a trial for selecting students for the inter-school Mathletics teams. In

5 At the schools at which the study took place students were attached to one of four houses. There was an annual competition between these houses for a shield.

this way, all students at the school had some experience of the competition. This was not so for the external mathematics competitions, the New South Wales Mathematics Competition and the Otago University Problem Solving Challenge, where only those students from the streamed top mathematics classes were able to participate. There was general agreement by these students that outside competitions made mathematics more interesting. For one student [s46:m7:J] the Otago Challenge was the only mathematics that was interesting — all the rest was boring!

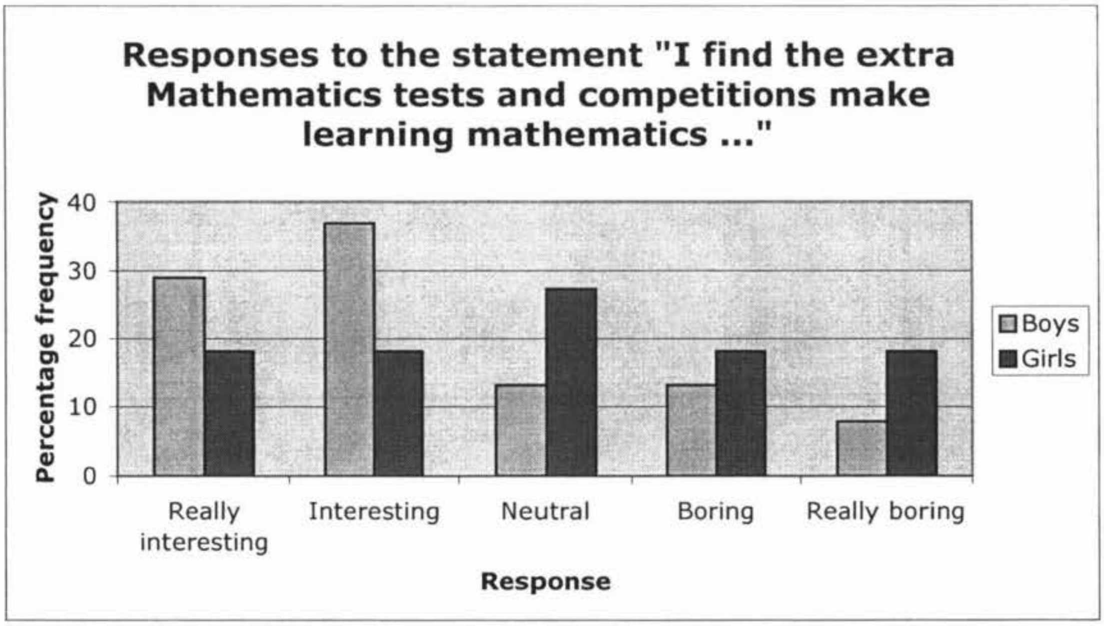
- *Otago Problem Solving. Fun and exciting. [s73:m8:J]*
- *We had an Otago test today. It was cool. I like puzzles. [s36:m7:J]*

However approval was not universal.

> *We had our final Otago Test today. I thought this was very boring. [s32:f7:J]*

Overall, about half the students who answered responded 'really interesting' or 'interesting'. However, when responses were considered by gender a different pattern for boys and girls was evident (Figure 4.1). Boys were far more likely to give a positive response (66%) than girls (36%), although the difference was not statistically significant.

Figure 4.1: Student responses to interest in extra competitions by gender



Further probing revealed that the apparent difference in the response patterns matched the gender composition of students in the top stream mathematics classes, in which about two thirds were boys. Thus the gender difference in the pattern of responses to interest in the external mathematics competitions appears to be related to the opportunities offered by streaming. Students in the top stream classes found these extra mathematics competitions more interesting than the others. The relative lack of interest for the less able mathematics students in these competitions may be due to the unsuitability of the level (see *unsuitable tasks* in section 4.4 later in this chapter) of the tasks in these competitions, combined with the lack of access to these experiences.

While some students were specific about the hands-on activities that they regarded as interesting, many students simply commented that they were more interested when the activity was "hands-on". This non-specific group have been included in the using ***manipulatives*** subset of hands-on activities. Manipulatives that were mentioned were Beanz[6], dice, 'boxes' (cubes and cuboids), calculators, computers, and the cubic metre model.

- *Hands-on measuring boxes and hands-on displacement of objects in water – fun. [s68:f8:J]*
- *We got to make rectangular prisms with cubes, that was COOL! [s35:f7:J]*
- *It was fun looking at 1 m^3. [s43:m7:J]*
- *We made different shapes out of 36 squares and then made a package for it. It was cool because I like hands-on maths. [s43:m7:J]*

It is difficult to separate the use of the manipulatives from possible confounding variables. For example, many responses from students who found the use of Beanz interesting also mentioned what they did with the Beanz. One specific activity involving Beanz that was frequently mentioned by students was "Finding the number of fish in a pond by sampling". Other students mentioned "Probability" and "Fractions" in relation to using these Beanz. Distinguishing whether the interest was due to the Beanz, the activity, the mathematical content, or any of the interactions between these factors was not possible in the course of this study.

6 Beanz is a commercially produced package for teaching mathematics that uses small variously coloured plastic bean-shaped pieces as manipulatives. Students refer to these pieces as Beanz .

Making and drawing activities were another group of hands-on activities that were frequently specified as being interesting. These activities are those in which the students gained some visual aesthetic appeal from the result.

- *Maths is fun when you can make stuff and have not much bookwork. [s55:f7:Q]*
- [Teachers can make things more interesting] *by making things and drawing objects because I like arty things. [s13:f7:Q]*

Particular activities that were mentioned in this regard were making or drawing 3-D models, tessellations, symmetry, hand stitching ("Like we weave it through the thing – that's for my times table"), Mäori patterns ("kowhaiwhai patterns"), "art in maths" such as enlargements of pictures, "cool as shapes with a protractor", colouring in circle diagrams and distorted grids, and making mathematics designs, e.g. tessellations and patterns.

Finally in this section on activities that students find interesting, survey response noted high interest when ***food*** was used in a classroom activity. Food was used as a reward: "when there is lollys or something and we have to do something to get one", and as a teaching aid, as was the case when two classes investigated fractions using either chocolate bars or home-made chocolate logs: "fractions when we used chocolate"; or probability (using pebbles). Bergin (1999, p. 93) noted that even though "there appears to be virtually no research on food generating interest, parents and teachers will agree with me that food grabs children's (and adults') interest above and beyond any novelty effect". The children in this study gave strength to this argument with the frequency and intensity of their comments.

- *Test the probability of a box of pebbles; really fun ☺ got to eat the pebbles. [s81:f8:J]*
- *Today at mathematics was really cool because T_A made caramel rolls for us to help us with fractions. We had to divide the roll using fractions and stuff. Then we finally got to try it. It was absolutely yummy. So that was one of the better and more interesting days in maths. [s99:f8:J]*

4.3.2 Groups

After hands-on activities, the next most frequently mentioned factor within the focus groups in engendering interest was working in a ***group***, especially in a group with friends. This is in accord with both Zahorik's (1996) interest-promoting factor called 'group tasks' and Bergin's (1999) 'Social Interaction' category. Student questionnaire responses indicated that the interest generated by group work appears to come from two sources: the opportunity to work with friends, and the ability to use talking and sharing as a mode of work.

- *Maths friend that you can work with. [s55:f7:Q]*
- *It's good when they let us talk quietly and laugh. [s82:f8:Q]*
- *More talking than writing lots of examples. [s86:m8:Q]*
- *Like doing normal work, just being able to talk too. [s84:m8:I]*

It was notable that some students did not simply want to work in groups as an end in itself. Comments on why group work was interesting such as "working in a group decusing idea's" (sic) and "being able to ask for help" suggest that social interaction was seen as a positive support for learning mathematics.

- *Let us do it in pairs or groups so we can share ideas and that makes it more interesting. [s101:f8:Q]*
- *Let us talk with other people when we don't know something or need help. [s31:f7:Q]*
- *When I sit with my friends makes me more interested because they can help me and I can help them. [s9:f7:Q]*

One student [s31:f7] indicated the level of interest of working in groups when she made these contrasting journal entries for consecutive lessons:

- *We worked in books in pairs today. We had to work out a pattern which was fun.*
- *We did patterns from books. It was really boring!*

Working in groups had the highest rating in terms of interest of all the questions in section A (the 'Activities' section) of the student questionnaire (mean = 1.8, standard deviation = 1). Only 4 of the 96 responses indicated that group work was boring. Even though group work was considered interesting, about 10% of the individual questionnaire responses for both boys and girls indicated that they still found things more interesting working on their own. One Year 7 boy simply said that it was more interesting when "working by myself", and an anonymous journal from a year 7 student noted "boring book work but at least we did it on our own".

About half of the boys and just over 60% of the girls in this study preferred working in pairs, while the remainder were more interested when groups were bigger than two. In the case of working in groups the boys modal response was 'interesting', while the girls' responses were evenly split between 'really interesting' and 'interesting', although once again there was no significant difference in the patterns of responses for boys and girls.

4.3.3 Mathematics

Bergin (1999) describes *competence* as one of the individual factors that influence interest. "People are more likely to be interested in a task or topic if they perceive that they will be competent at it or that their incompetence will not be publicly highlighted" (p. 90). Many students in the present study also found that *success* and *suitable tasks* were associated with increased interest. In the focus groups they reported being interested when "doing well in tests", "knowing that you're getting it right", and when they didn't "feel stink when the teacher explains".

- *It was fun because I'm good at it. and I didn't like it much because I did not know much. [s36:m7:J]*
- *I don't really like tests — and one week later — We did a test. I got 99%. I found this fun. [s32:f7:J]*

While there is agreement from teachers in this study that success from working on suitable tasks increases levels of interest in learning mathematics, finding mathematics activities and content at a suitable level is problematic. Some students in the study preferred their work to be easy (sometimes with qualification: for example, one student said, "I enjoy doing some work in books only if it is easy") whereas others preferred a challenge:

- *I enjoyed the quick basic facts test and the formulas because they were a challenge. [s43:m7:J]*
- *s67:m8:I* — *Well, easy stuff. You're not using your brain or anything just figuring it out straight away.*

  Researcher — *So it's the thinking that is the interesting part?*

  s67 — *And challenging, which makes it fun.*

  Researcher — *What if the challenge is too hard?*

  s67 — *Well then it's more fun still. It's still fun, because I've had things that are way too hard and I still do it and find it fun.*

Asked in the questionnaire if they were more interested in learning Mathematics when there was a *challenge* involved, student responses were quite variable (mean = 2.7, standard deviation = 1.1: 49% indicated agreement, 23 indicated disagreement, with 28% neutral), again with no significant gender differences in the pattern of responses.

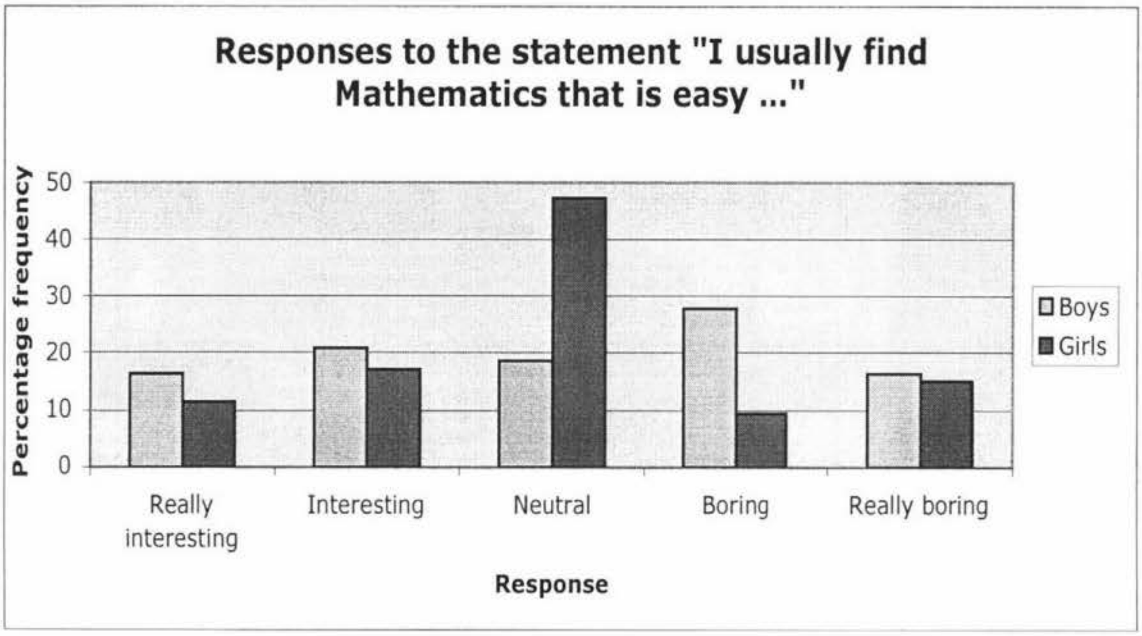
When students were asked if they were more interested in work that was *easy* the average response was 'neutral' for both boys and girls (see Figure 4.2). But the pattern of responses was quite different. The high standard deviation (1.2) was partly because boys gave very few 'neutral' (only 19%) responses, and had a fairly symmetric response distribution with 44% of the responses negative (and 16% – almost one in every six – responding with 'really boring'). The girls' responses also had a high standard deviation, with a large proportion (15%) responding 'really boring'. However nearly half the girls (47%, compared with 19% for the boys) responded 'neutral'. The differences in the patterns of response for boys and girls were significant ($p = 0.03$).

Two other aspects of the mathematical content raised by students in the focus groups were *practical tasks* and mathematics that was related to other knowledge, referred to by Zahorik (1996) as *personalized content*. Zahorik uses the term 'practical tasks' to refer to work that has some useful application outside class. He defines 'personalized content' as that content in which the student already has an interest. It is not just content that is already individually interesting to a student that promotes interest; interest is frequently increased by any content where a student already has some prior knowledge whether there is already individual interest present or not (Alexander, Jetton,

& Kulikowich, 1995; Bergin, 1999). Specifically, students in this study noted tasks related to themselves to be interesting.

- *Measured heart rate – fun – our own heart rate. [s68:f8:J]*
- *We did our pulse rate today which was cool but the book work was a bit boring. [s73:m8:J]*

<u>Figure 4.2: Student responses to interest in 'easy' mathematics by gender</u>



Practical tasks and personalized content are often related, as sometimes the practical tasks involve an individual's informal knowledge from outside the mathematics classroom. Tasks cited by students in this study such as marking out the athletics track, "real-life (e.g. GST)", and measuring netball and padder tennis courts may be interesting because they are both *practical* and *personalized* for particular students. One student cited making pop up cards as an interesting practical task, and made the following comparison:

> *Not as interesting as games, but it's better than other stuff like writing down heaps of things doing those books that we have to do. [s84:m8:I]*

Practical tasks were frequently mentioned in the student focus groups as being interesting, but personalized content was not. Even so, two students made comments supporting the fun in using personalized content, when they suggested that it was more fun when:

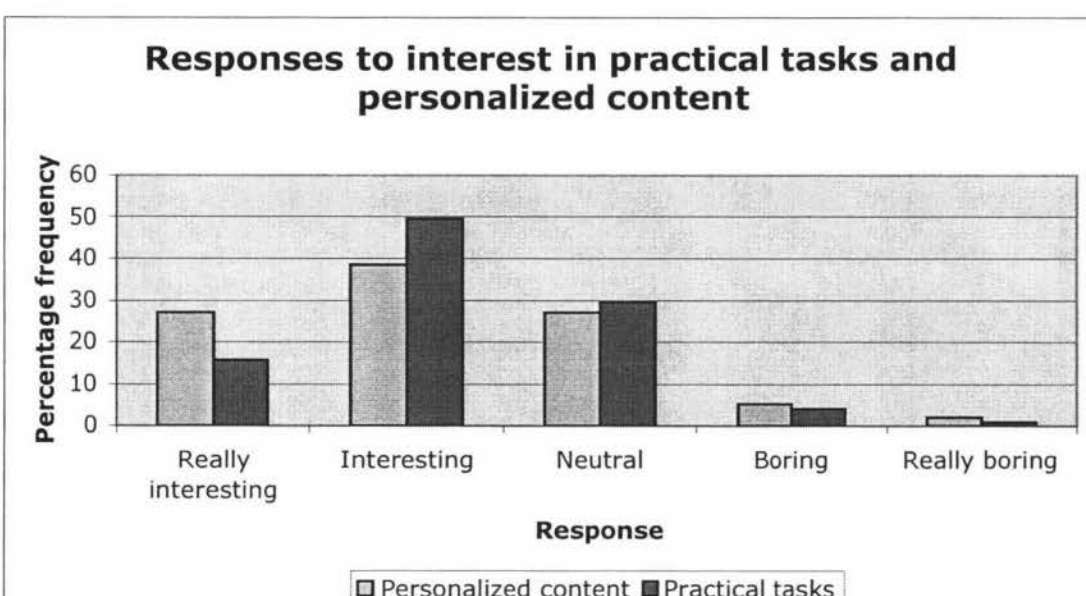
- *it is a topic that I enjoy and I know what it is about. [s95:f8:Q]*
- *doing things I already know how to do. [s13:f7:Q]*

One student who played badminton reported increased interest in a mathematics question that included a reference to the size of a badminton court.

Yes. Oh yeah, I know this. [s84:m8:I]

Even though mathematics that related to previous student knowledge was not mentioned specifically in the student focus groups, a question about each of the *practical tasks* and *personalized content* sections of Zahorik's (1996) study was included in the student questionnaire. The student response patterns (see Figure 4.3) relating to both the personalized content and practical tasks factors were very similar. Over 60% of the responses for both factors were positive with respect to interest, with very few negative responses (7% and 5% respectively for personalized content and practical tasks). There was no significant gender difference in the pattern of responses for either factor.

Figure 4.3: Student responses to interest in practical tasks and personalized content



When asked specifically to identify mathematics content, either topics or ideas, students mentioned activities more frequently than particular content. While this happened with all the instruments used it was particularly pronounced in the questionnaires. The questionnaire had three sections, labelled *Activities*, *Content*, and *General*. Section B, the *Content* one, required students to "write down any mathematical ideas that you find interesting". Even though the label of the section and the subject of the statement were both related to content, and the first section in the questionnaire had already dealt with activities, students often replied with responses related exclusively to activities, and nothing related to content. This may have been because of the carry-over from the previous section relating to activities in the questionnaire. However, the lack of reference to content was also present in the focus group discussions where the order of focus was reversed (activities first then content). At the very least, the interesting content suggested by students was usually associated with learning activities that were also deemed to be interesting.

Mathematical topics that students found interesting, with the number of times they were mentioned in the questionnaire in brackets (no brackets means only one mention) are listed below. The content marked with an asterisk was frequently mentioned in conjunction with a particular teaching activity and thus the interest for this content may be related to the activity rather than just the content, for at least some of the respondents.

*Problem solving (12)**
*Estimating from sampling (11)**
*Probability (11)**
*3-D shapes (10)** (making nets and models)
*Measurement (7)** (going outside to measure)
*Circumference of circle (6)** (marking out big circles outside)
*Area of circle (5)** (marking big circles outside)
*Enlargements (5)** (this sometimes involved enlarging cartoon drawings)
Algebra (4)
*Statistics (4)** (they each did a statistics investigation of their own choosing)
Addition (3)
Area (3)

Decimals (3)
*Fractions (3)** (using food)
Perimeter (3)
Time (3)
Times tables (3)
Angles (2)
Division (2)
Percentages (2)
Pythagoras (2)
Subtraction (2)
*Temperature (2)** (going outside to measure temperature)
Angles of triangles
Archimedes (experiment with water and objects)
Basic Facts
Computation
Estimating
Graphs
Number
Prime Numbers
Ratio
Reflection
Related to science
Square root
*Volume/Capacity** (cubic metre model)
Weight

Eight of the 96 students replied that there were no mathematics ideas that they found interesting, and thirteen made no response to this part of the questionnaire.

In order to probe *topic interest* students were asked to rate each of the major strands and sub-strands of the New Zealand curriculum (Ministry of Education, 1992), using a Likert scale of 'really interesting' as 1 through to 'really boring' as 5. A summary of the results showing the frequency of student responses is shown in Table 4.2. The sub-strands, and 'All of mathematics', are listed in order of increasing mean value (and then in order of increasing standard deviations), so that the more interesting the students in the study found the topic the higher up the table it appears.

Table 4.2: Student responses to interest in the MINZC sub-strands

Response / *Topic*	Really interesting	Interesting	Neutral	Boring	Really boring	No response	Median	Mean	Standard deviation
Probability	22	42	16	6	4	12	2	2.2	1.0
Problem Solving	25	25	17	9	3	23	2	2.2	1.1
Symmetry and transformations	21	36	25	10	2	8	2	2.3	1.0
Geometry	23	35	22	10	3	8	2	2.3	1.1
Algebra	11	28	25	12	4	22	3	2.6	1.1
Statistics	19	31	22	14	8	8	2	2.6	1.2
Computation and estimation	8	32	30	12	3	17	3	2.7	1.0
Measurement	11	31	30	18	4	8	3	2.7	1.0
All of mathematics	**6**	**27**	**42**	**11**	**4**	**10**	**3**	**2.8**	**0.9**
Measuring time	11	15	37	10	10	19	3	2.9	1.2
Number	7	22	36	25	5	7	3	3.0	1.0

The four topics, Probability, Problem solving, Symmetry and Transformations, and Geometry were distinctly more interesting to students than the others. Number and Measuring Time were the least interesting to these students. All individual topics apart from Number had means less than 3 (interest level more positive than neutral), indicating that students were generally more interested than not in each of the topics in the mathematics curriculum. However, when asked to rate 'All of mathematics' it receives a less affirmative response (median = 3) with only 33% of students finding it interesting. It appears as though interesting experiences in specific topics in mathematics have less transfer to mathematics in general than do boring ones. Or perhaps it might indicate that when students think of "All of mathematics" they think of numbers first — and the topic Number was the least interesting of all curriculum topics. Given that previous research confirms that interest levels decline as students move to secondary schools (Eley, 1999; Mitchell, 1993) this result gives cause for concern.

4.3.4 Classroom Variables

How the classroom is managed and what happens while mathematics is being taught also impact on interest. According to the student reports the teacher had a big influence on the level of interest. When teachers in Zahorik's study were asked what actions they took to enhance interest in their lessons, *teacher enthusiasm* was the sixth most frequent class of actions they reported. The characteristics of Zahorik's teacher enthusiasm "include being humorous and having fun, describing personal experiences to students, participating in tasks as an equal group member, showing excitement, and communicating a sense of purpose, direction, and organization to students" (1996, p. 556). Bergin refers to a similar construct as 'modelling' and suggests that "instructors might be more effective if they established a personal relationship with the class through appropriate personal disclosure" (1996, p. 94).

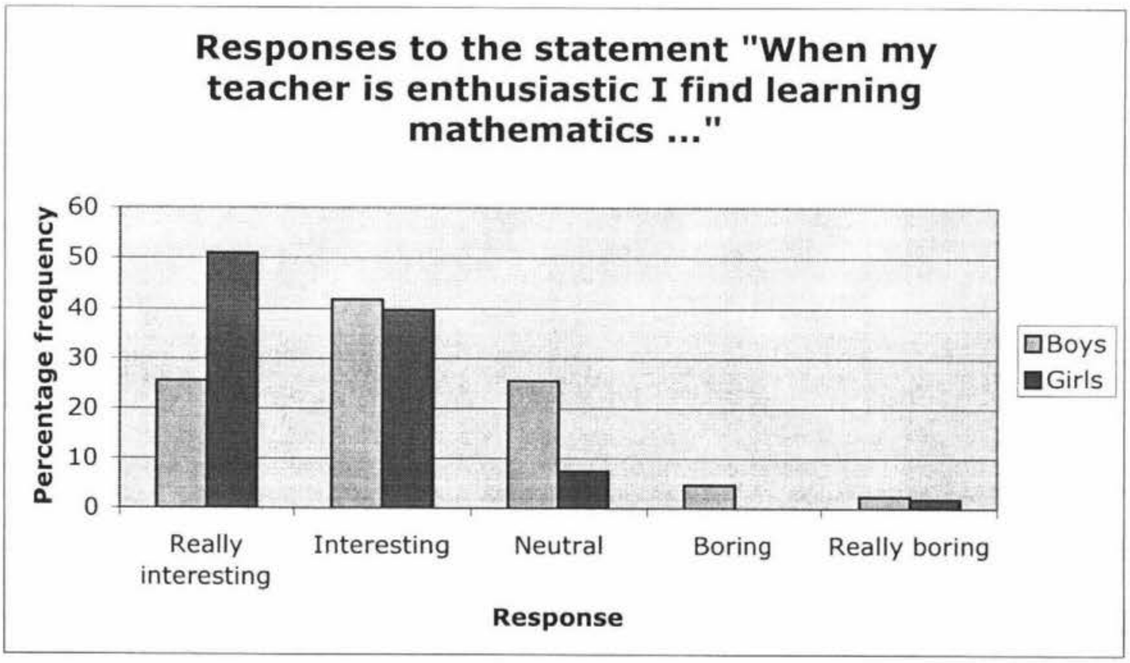
The students in this study put teacher enthusiasm much higher up the list – in the top three factors ranked in the questionnaire (along with hands-on activities and working in groups) – than the teachers in Zahorik's study, in relation to making classroom teaching interesting with a mean score of 1.9 (indicating high interest). The response patterns for boys and girls (see Figure 4.4) were significantly different ($p = 0.02$), with over 50% of the girls saying really interesting and 40% responding interesting. The corresponding percentages for boys were 26% and 42%, with a further 26% neutral. Thus while students noted teacher enthusiasm as a positive contributor to interest, girls were more favourable in their rating than boys.

Further support for teacher enthusiasm was evident in the focus groups, and in all open-ended questions in section C of the questionnaire. Many of the comments simply suggested that an "enthusiastic teacher" was better for interest, or that a "boring teacher" was counter-productive with respect to interest in learning mathematics.

Students generally found classes more interesting when the teacher got excited, was in a good mood, was a "cool teacher" or a "calm teacher", was humorous (although there was one exhortation for "no lame jokes"), treated the students well ("be nice to us when we make mistakes", "treat you the age you are"), made learning fun, encouraged, had competitions against the class, and told interesting stories. In order to make mathematics interesting students wanted teachers to be happy and not negative, to have expression in their voice, to show interest in mathematics themselves, and to be a "little crazy". Students expressed it thus:

- *Be positive and cheerful because it sparks the class up. [s53:m7:Q]*
- *T_D tells jokes which makes it more interesting. Also talking about chance when we had to fish [a sampling activity] – he kept getting excited! [s31:f7:I]*
- *I suppose just being interested themselves. If they're not really interested then you don't get really interested. [s84:m8:I]*
- *Being a little crazy (like when we were doing a basic fact test for one minute and T_D yelled 'Stop' which made us all jump, that was fun). [s35:f7:Q]*

Figure 4.4: Student responses to interest in teacher enthusiasm by gender



The students noted other aspects of the teacher's involvement that made mathematics learning interesting, especially those that supported students' learning. These actions, termed *student progress* actions, are teacher actions that enable students to make progress in mathematics. For example, students found that they were more interested when they knew what it was that they were supposed to be doing ("when I get what I'm doing" [s81:f8:Q]), and when they understood the mathematics, and – although not always a requirement – got rewarded with good marks as a result. Students wanted teachers to give clear instructions, be available when needed ("make sure you know what you're doing" [s93:f8:Q]), explain the mathematics well, and help them understand the mathematics curriculum ("talk through the answers with us" [s12:m7:Q]). One student journal contained the following three entries on consecutive days:

- *I still don't get it. T_A won't explain it properly.*
- *Mr F [relieving teacher] explained it really well.*
- *It was really fun; T_A explained it well.* *[s96:f8:J]*

This continues a theme expressed by students throughout this study, that things that are interesting in class ought not be simply gratuitous, that they should also have a mathematics learning component to them.

> *The patterns were interesting because I learnt how to figure out the rules. [s39:f7:J]*

Another facet of classroom management that was a recurring theme expressed by students was that they wanted to make their own choices as often as was practicable. Teachers in Zahorik's study reported using giving students choice as a way of generating interest, and Zahorik labelled this class of actions *student trust*. Student trust is about allowing students to make their own choices, have input into classroom activities from the planning stages onwards, and even "to play the role of teacher" (Zahorik, 1996, p. 555). Student trust was investigated through responses to the statement, "when I am allowed to **choose for myself** in the classroom I find learning mathematics ..." in the questionnaire. There was little variation in the responses to this question, and the mean was 2.4 (median = 2). The response distributions for boys and girls were virtually identical, with overall 55% of students choosing 'interesting' as their response, and only 8% responding negatively. Specific activities mentioned relating to student trust were: using students to explain, "20 questions when pupils do it", peer testing, "working with partner on own choice of work", and working at their own pace ("give you lots of time to do it").

> *We finish off our Maths Circus game today that was the best maths day in my life. Own pace. [s6:f7:J]*

Simply having choice in what they do — even when the choice is limited — appears to increase interest for some students.

> *I like it when we have a sheet that has activities on it and we have to complete them but in any order and some are hands-on and some are written work. [s10:f7:Q]*

The student quoted above showed that, not only was it more interesting to be able to choose, but also that a *variety of activities* made mathematics more interesting, with novel activities especially interesting. The journal of another student concurred:

- *Mathematics is fun when we do all different things and not just the same for the whole lesson. [s37:f7:Q]*
- *It was interesting because we had not done it. [s36:m7:J]*

One way in which teachers were able to vary the activities in their mathematics classrooms was to tell stories about the mathematics ideas. Some students found that these stories added to the interest in what was to be taught.

> *We did volume. T_D told us about Archimedes. It was really interesting. [s49:f7:J]*

Analysis of the questionnaire probe as to whether using a variety of activities was related to increased interest provided an almost identical overall pattern of responses to the probe for students using choice in the mathematics classroom.

The *classroom environment* also had an effect on the interest that some, but not all (14% stated that it made no difference, and many more did not answer this section of the questionnaire) students had in learning mathematics. For those that considered environment factors did have an effect on interest, positive statements related to: colour (9 students) ("makes me less interested when the colours are dull" [s58:m7:Q]); working in groups and social interaction (11) ("how the desks are arranged because you can sit with lots of different people" [s38:m7:Q]; "lots of talking"); being or seeing outside (6); different people and different classrooms for mathematics (2) (as mathematics was streamed in this school most students were not in their home room nor with the students from their home room during mathematics lessons); noise (2) ("quiet" and "a little bit of noise"); "computer", "diagrams as opposed to bookwork", "use students to explain" [s96:f8:Q], "things to look at", "atmosphere happy and laughing", "competition", and "lots of work " all had one student mention. Negative statements related to: disruptive behaviour by other students and music (both had 2 comments); fluorescent light and too hot (both 1). One student wrote:

> *Maths is more interesting when the people around you are nice and the teacher isn't boring and when there are windows to look out and lots of colours in the room. [s51:f7:Q]*

4.3.5 Positive Affect

"Emotions have a strong influence on the development of interest" (Bergin, 1999, p. 90). This study investigated two areas of positive affect that were raised in the student focus group discussions: whether mathematics was more interesting when students *felt good* or when it was *fun*. Although negative emotions can also increase interest (Bergin, 1999; Iran-Nejad, 1987), students in the focus groups did not mention this aspect, so it was not included in the study.

Students generally reported that they were more interested when they felt good.

> *Yes. When I feel good it makes me more interested. [s98:f8:Q]*

The largest class of responses relating to feeling good were to do with *student progress*—students felt good when they knew what they were doing and were having success, and conversely felt worse when something was missing in this regard. Fifteen per cent of students commented positively on being able to understand or do something. Students felt good:

- *When you understand what's going on. [s79:f8:Q]*
- *When I can do something well. [s68:f8:Q]*
- *When I have the highest marks in a test or get an answer no-one else can get. [s63:m8:Q]*
- *When the maths is easy. [s91:m8:Q]*
- *I think that when you have learnt what you are getting taught and you know how to do it well then you feel good. [s57:m7:Q]*

Progress and the associated good feeling was also couched in terms of a sense of accomplishment to overcoming an initial challenge:

- *When I have accomplished something that I found a challenge at the start. [s9:f7:Q]*
- *When I improve heaps. [s19:f7:Q]*

Others acknowledged that teacher support was an essential ingredient in being successful and feeling good. They felt good:

- *When I get it or get help from the teacher. [And I don't feel good] when I don't. [s81:f8:Q]*
- *... when I know how to work out problems, or if they have been explained really well. [s78:f8:Q]*
- *A teacher in a good mood always helps me because if you need help they are more likely to give it to you. [s53:m7:Q]*

Conversely, students felt bad, and lost interest, when they were not having success. For some, the cause of this was lack of support from the teacher:

- *Well when I find things really hard and the teachers won't help I get frustrated and feel as if I hate Maths; [s88:f8:Q]*

some simply felt bad about not succeeding:

- *Not knowing how to do something. [s77:f8:Q]*
- *When I get stuck on something and find it difficult to understand; [s95:f8:Q]*

some compared themselves unfavourably to others:

> *When I don't know anything that I'm doing and everyone else does; [s84:m8:Q]*

and one commented on absences from school causing difficulties. One student suggested a need for "completing something before moving onto the next level".

Many of the students (23%) related their positive or negative affect with respect to student progress to good marks or poor marks respectively, or to being singled out in this regard.

- *I don't feel good when I get called on to answer questions because I am afraid of getting them wrong. [s66:f8:Q]*
- *I feel good when I am praised, and don't like it when I get told off for little mistakes. [s8:f7:Q]*

Other factors that made students feel good, and that have been mentioned before, were games, hands-on activities, enthusiastic teacher, jokes, new things, and working in groups, especially with friends "… and being able to ask them stuff". Also, four students commented that they felt good when they were already interested in a topic, highlighting the inter-relatedness of interest and positive affect (and in the case of one student, of learning as well: "When there's something I like learning I am more interested and I learn more." [s60:f7:Q])

The main factors that made students feel bad were tests, bookwork (especially written work), the teacher and repeating the same pattern of lesson or the same work over and over again.

Students also generally found learning mathematics interesting when it was *fun*. They reported having fun when they: played games, did hands-on activities, had an enthusiastic teacher (especially one that was humorous), worked in groups, went outside the classroom to work, used food in the lesson, were making progress ("When I get what I am doing" [s81:f8:Q]), had competitions, had choice as to content and pace, solved problems, made things, were challenged (specifically by extra mathematics activities such as the Otago University Problem Solving Challenge), and had variety in the lesson.

- *Mathematics is boring but it would be less boring if we had fun activities like games. [s3:f7:Q]*
- *When we pick what we get to do. [s91:m8:Q]*
- *Yes. When you can play games but still learn it's a fun way of learning. [s88:f8:Q]*

- *Yes. When it's fun it's more interesting because you seem to get involved more. [s65:m8:Q]*
- *When we play games or if you understand a topic really well it makes it fun because you know what you are doing. [s101:f8:Q]*

That the above list encompasses most of the factors mentioned in what makes mathematics interesting shows the close relationship between children's understandings of *fun* and *interest* (Middleton, 1995). Two students commented on the reciprocal relationship — they expressed the idea that it was more fun when they were interested.

Frequently students reported not having fun when they just did bookwork or sat and listened. Negative affect related to not having fun or not feeling good will be addressed more fully in the following section.

4.4 What Makes Learning Mathematics Dull or Boring

The previous section dealt with what students found made learning mathematics interesting. There is another side to this story: "Classroom boredom has been well documented in the research literature" (Mitchell, 1995, p. 424). Some would claim that mathematics is the best place for decreasing classroom boredom because it is the curriculum area that has the worst record with respect to students failing in school (National Research Council, 1989).

In his 1996 study Zahorik asked teachers to detail the actions that they avoided in order that students would not be bored. Zahorik found that the most common class of actions that teachers identified as boring was *sedentary activities*, where students were not actively involved. Teacher actions that were considered to be "harmful to interest were lecturing, explaining, giving directions, reviewing, taking tests, reading textbooks, doing workbooks, and taking notes" (p. 557). The class of activities referred to as 'sedentary activities' is the approximately the converse of the 'hands-on activities' of the previous section.

The students in this study concurred with the teachers in Zahorik's study. The focus groups the discussion about what made mathematics dull included 'bookwork', closely followed by 'tests', and then 're-learning when you know it (teacher going on)'. Some students took this opportunity to reinforce their preference for games by saying that it was boring when there were not enough games, although there was one game, Maths Gym, that students found boring. The student journals reflected the views that sedentary activities were dull. From the 62 student journals 53 references from 26 students condemned bookwork as being boring, and only 3 references from 2 students reported bookwork as interesting (and one of those specified that it was interesting that day because it was hard).

- *Book work, got boring after a while, dragged on and on and on and on [s68:f8:J]*
- *Boring book work! and I hate book work. [s43:m7:J]*
- *Did patterns and relationships. Ok but they were too easy but at least we did it orally (not from those stupid books!) [s35:f7:J]*
- *Boring bookwork. We did too much bookwork. [s73:m8:Q]*

The condemnation of this sedentary activity, was further supported by extreme dislike of another sedentary activity, using worksheets (25 'boring' references from 17 students, and 5 'very boring' ones from 3 students, and only 3 'interesting' comments from 3 students).

- *It was boring working from a worksheet. [s43:m7:J]*
- *BORING – Did a boring capacity worksheet, it was really BORING! [s35:f7:J]*

Disdain for these activities, referred to as "written work", had also been noted by some students in the questionnaires. As one student put it, mathematics was fun when "you are making things and not doing much writing" [s86:m8:Q].

Other comments relevant to the boredom of sedentary activities related to having nothing new to do. Waiting was a problem in this regard, for example waiting for a teacher to help when a student was stuck, or waiting for others to finish a test. One student suggested that the teacher should "not keep us waiting as some of us get bored easily". Repetition was another problem. Comments from students in this regard were: "basic facts every day", "area tests over and over again", "re-learning when you know it (teacher going on)", "not blabber on all the time, and going over what to do heaps of times" [s82:f8:Q] and "Basic facts test and NCM [National Curriculum Mathematics text] (again). Was more interesting watching the window cleaners" [s66:f8:J]. Students simply wanted to get on with whatever was required. The other sedentary activity disparaged in the journals as being boring was test taking.

One form of hands-on activity, *competition*, seems to have two sides with respect to interest. Competitions that students in this study experienced were sometimes individual, and sometimes between groups (boys versus girls, inter-house). They were often described as interesting, and sometimes as boring. While this division occurred with other types of activities, there was a greater polarisation with respect to competition. Some students' explanations suggested that competitions are more interesting when one wins, and less interesting when losing. According to Bergin this polarisation is likely in "situations that emphasise competitive, ego-involving goals are more likely to result in disengagement if a person perceives a lack of ability" (Bergin, 1999, p. 91).

Another class of activities that teachers avoided in Zahorik's 1996 study in the quest of decreasing boredom was *unsuitable tasks*. Likewise, this was an area that the students in this study also found increased boredom. Boredom increased when tasks were too easy ("not being extended"), too hard ("extra tables that I can't do"), too complicated ("board work that's hard to follow"), too long, too rushed (students have to rush to finish), or in some way inappropriate for the students (for example, when questions in a test were not clear, students saw this as being unfair, and found this to be an unsuitable task). Many of these criticisms relate to students not experiencing success, or being able to make progress. Students commented that they were more bored when they could not understand.

Teacher insipidity (Zahorik, 1996), the converse of teacher enthusiasm, was also regarded as decreasing interest in mathematics classes by the students in this study. One student said in an interview:

> *I've had real unenthusiastic teachers before and then I started slacking off because of it. There's no will to learn. [s67:m8:I]*

Several students mentioned that when teachers were grumpy, or unhelpful, this increased boredom. While not proposed as generalisable, many negative comments (related to mathematics being boring) were made about having a relieving teacher. These were mostly from students in one class where the teacher was absent for quite long periods of time.

The other class of actions that students thought decreased interest paralleled Zahorik's (1996) classification of *student mistrust*, the counterpart of student trust. Teachers use student mistrust when they act in a way that decreases student participation. Some students in focus groups reported losing interest when they are not able to work at their own pace, when they were reprimanded for being too noisy while working at mathematics in a group, and when they felt put on the spot.

While working in groups, especially with friends, was strongly supported by the students as a way to increase interest, students noted that peers could sometimes be annoying, especially when "others in the group don't pull their weight". One girl in her journal noted another boring factor.

> *Drawing circles of 40 m and 20 metres using circumference and diameter. Got put with the boys so it was boring. [s39:f7:J]*

When students worked with their friends they sometimes made more noise, and one student objected to the "teacher growling when working things out in a group". The counterpart to working in groups, doing individual work, was preferred by a few students.

Interest in a particular topic or activity is not universal. Individual interests vary from person to person. Some activities and ideas are boring to some and interesting to others. The journals provided ample evidence of situations where this polarisation of student opinion occurred. Both 'easy mathematics' and 'basic facts' had 10 mentions of being boring (from 8 students). They also had about the same number of 'interesting' comments from a comparable number of students. Going outside and measuring the netball courts, investigating the relationship between the circumference and diameter of a circle, and other ostensibly *practical tasks* using *hands-on activities*, generated mostly 'interesting' comments (34 comments from 15 students), but were also seen as boring by a solid core (9 from 7 respectively) of students. One explanation for this latter polarisation may be because these so-called practical tasks had no utility-goal relevance (Bergin, 1999; Boaler, 2002; Nardi & Steward, 2003) for the students who thought it boring. This lack of personal relevance would then have made these *artificial tasks*, another class of tasks the teachers in Zahorik's study sought to avoid (1996). One student gave examples of tasks that were artificial and practical to her.

> *Some of it's* [probability's] *lame. Like 'what's the probability of a rhino busting into your classroom in 5 minutes?'. But some of it's cool like the weather. ... Yes sort of real life. Closer to reality than rhinos. [s2:f7:1]*

Journal comments relating to 'formula and patterns', games, the Otago University Problem Solving competition, and symmetry all showed varying degrees of polarisation of opinion.

4.5 Making Learning Mathematics Interesting: Student Suggestions

Question fifteen in the questionnaire specifically asked for students' views of what teachers could do to make mathematics interesting. The responses to this question essentially followed the reports of what was interesting in the students' mathematics classrooms. The numbers in brackets in the following paragraph indicate the number of student questionnaires that contained the corresponding suggestion.

The most prevalent response to this question was to *play games* (35), with the aforementioned qualification that the games should not be simply gratuitous (5), but have some mathematical purpose.

- *Try and put more normal activities like every day things in maths, like writing in books, kind of make it into a little game. Just try and make more things into games which everyone likes doing games. [s84:m8:1]*
- *Things that are fun do make it more interesting. If you can put a game into it, that helps. [s24:f7:1]*

There were nine mentions of hands-on activities that did not include games. Other ways of generating interest in mathematics suggested by students were to use *food* (7) in teaching the mathematics (especially *chocolate* (2)), employ a *variety* (7) of teaching activities ("Do something different every once in a while" [s9:f7:Q]), don't just use board work or textbook work (4), get students to work in *groups* (4), go *outside* (4) for measuring tasks, play *music* (4) quietly in the background, use *real life* (3) examples giving students *choice* (3) and *using students to explain* (2) the work. And use other forms of assessments than tests (3).

Students suggested that teachers ought to *be enthusiastic* (17), *funny* (17) and *happy* (6); and to *tell jokes* (10) (well, good ones anyway!). Further to these demands on teachers, students felt that mathematics teaching support when they needed it (10), being rewarded (5) for good work, having the mathematics explained well (3) and getting the answers talked through (2) while not having to listen for too long (5) at any time, would aid interest in learning mathematics. If teachers were able to make learning fun (3) and tell interesting stories (3), mathematics would be even more interesting. Perhaps teachers should be like this one:

> *We have a fun teacher who makes you want to listen to him. He has lots of expression in his voice. He's enthusiastic—which makes you want to do it. His enthusiasm makes it more fun and easier. [s24:f7:I]*

4.6 Overview

Most of the students in this survey reported in the questionnaire that they believed that it was important for teachers to make mathematics learning interesting. Many students were able to support this claim by justifying why they considered it was important. These reasons involved one or more of the following beliefs: that higher levels of interest were related to increases in the quality and the amount of learning, the level of concentration and diligence of students, and also the degree of cooperation students showed in mathematics classes; and that higher interest levels would improve job prospects and life skills in future.

The responses showed that students thought that what made learning mathematics interesting were hands-on activities (moving around, games, competition, using manipulatives, drawing and making things, using food and problem solving), working in groups, having an enthusiastic teacher, making progress, using suitable tasks (challenge, right level, know what's needed to do, extra mathematics competitions where suitable), exercising choice, having a variety of activities (especially important as different students are often have contradictory interests), practical tasks and personalized content where possible, emphasising interesting content, and feeling good and having fun in an interesting classroom environment.

Chapter 5: Teacher Views

5.1 Introduction

This chapter presents a qualitative analysis of the views of the 5 teachers involved in the study with regard to student interest about learning mathematics in intermediate schools. The results come from the initial focus group interview, the teacher questionnaire, a follow-up interview, and teacher journals. These four instruments were designed to work in tandem to develop a description of what teachers believe interests their students in learning mathematics at school, what teachers do to create, develop and maintain this interest, and how important teachers think such interest is in the teaching and learning of mathematics. In what follows teachers' comments used in this study will be attributed to both the teacher and the instrument by which the comment was elicited. For example, the five teachers are referred to as T_A through to T_E. [T_A:Q] indicates a comment made by teacher A during the questionnaire; [T_E:FG] indicates a contribution from teacher E during the focus group discussion. Other instrument codes used are 'I' for 'interview', and 'J' for 'journal'.

5.2 Importance of Student Interest in Classroom Teaching

All the teachers in this study thought that it was very important to make learning mathematics interesting for their students. However, it was notable that this was a challenge for most teachers, with only one teacher confident that students in his class unanimously found mathematics interesting.

I think I do make mathematics interesting. [T_D:Q]

Two related this to teacher enthusiasm, and three suggested that bored children do not learn well. When asked how important it was for teachers to make mathematics interesting for their students, they summarised it this way.

- *Very. It [mathematics] is the type of topic that children think they are good at or not. I believe it can be taught to a point and children need to have basics for future life experiences. If it is not interesting they will not learn and simple facts that are important in life will be lost. [T_E:Q]*

- *Extremely – a bored teacher is not motivating. Children can see right through you. [T_A:Q]*
- *Very. Many students switch off if they find maths too hard/too easy/unstimulating. [T_B:Q]*

Further comments related interest to how mathematics as a discipline is taught and perceived. Teachers thought that the idea that mathematics answers are either right or wrong (and implicitly that there is only one way of proceeding) may limit both learning and interest, and this may start right at the beginning of school. And interest itself may be moderated by ability—students with little mathematics ability may not ever find mathematics interesting.

All the teachers in this study valued student interest and felt that interest was linked to paying attention, staying on task longer, and thus achieving relatively more in terms of learning outcomes than when interest is not present. Comments to this effect were:

- *I think it's very important purely because I know that I will only learn if I'm interested in something. [T_C:I]*
- *I guess for anything without the interest they are not going to do well. I mean that is like anything – sport – that's everything in life basically. If you haven't got an interest you are not going to do it well and you are not going to put the full effort into it, so it is very important. [T_E:I]*

5.3 Classroom Activities Teachers Use to Promote Interest

Hands-on activities

Hands-on activities refer to a range of activities in which the student is an active participant rather than a passive listener. The term includes the use of manipulatives. In Zahorik's 1996 study the teachers' use of hands-on activities was the prime way of increasing interest in classroom topics. The teachers in the present study had similar views and practices to those in Zahorik's study. They all thought that hands-on activities were either very interesting or interesting for their students, and they all used such activities either a lot or sometimes. However, while generally positive about hands-on activities, one teacher noted that interest was partly because hands-on activities offered students more opportunities to take part in off-task behaviour.

> *I think it's more a case that it's easier for them [students] and it's deemed more as play and they can talk. They can have off-task time talking with hands-on stuff. [T_E:I]*

Reported activities or manipulatives used included:

- *Beanz* (for teaching fractions, percentages, ratios, probability, factors, multiples and estimation from sampling)
- cuisenaire rods (for scale drawing)
- drawing enlargements and kowhaiwhai designs (and other types of art work)
- rolling out and measuring circles to investigate pi
- making nets and three-dimensional models from these nets
- gathering data for statistical investigations
- dice, coins, and mirrors,
- using pairs of compasses for drawing circles
- investigating tessellations, using "the old click click click thing" [T_C: I] for measuring distances outside
- measuring out a hectare
- making cubes and filling a one cubic metre container with these cubes
- investigating Archimedes' principle using water
- isometric drawing
- using food (chocolate log, Hersheys bar, chocolate pebbles) for fractions and probability
- puzzles such as soma cubes, tangrams and logic puzzles
- origami
- using thermometers for developing ideas on temperature
- making sundials and sand clocks for work on time
- measuring pulse rates for statistical data (and other forms of data gathering)
- making shapes for geometry, and
- designing fun park landscapes for mapping (students "appeared to be engrossed in this" [T_B:J]).

Comments from teachers about the above activities included:

- *Finished with drawing different types of lollies from a bag – had to explain how the odds had changed and what the chance of them getting a certain type of lolly was. All VERY ENTHUSIASTIC. [T_B:J]*
- *I actually went out and bought a Hershey's bar between every two people so we could actually break it up into half then quarter and the kids absolutely loved that. [T_C:I]*
- *Children really loved origami, soma cubes and isometric drawings. They found the tangrams frustrating! [T_B:J]*

The most common type of hands-on activities was ***games***. Games were used to start lessons, for maintenance, to teach mathematical ideas and as a reward for good behaviour or for completing work. Games included the 24 game, Maths Bingo, Two Amigos, Taranaki sprint, Buzz, Whizz-Bang-Boing, dice games such as Snakes & Ladders, Snail Race, Killed a Gambler, and a variety of mathematics board games – including ones that students had designed and made themselves (fractions and percentage dominoes, snail race). Teachers reported that a problem-solving computer-based activity/game called Maths Circus was particularly interesting – "children LOVED this" [T_B:J]. Competition between groups within the class (boys versus girls; houses) was often part of the game ("kids really like competitions"). That games were ubiquitous may have been because, as one teacher put it, "You can make anything into a game" [T_A:FG]. Teachers commented on the interest generated by playing games or having competitions with their students.

- *Kids love competition. Anything that I do where it's you guys against them. [T_C:FG]*
- *Anything that you can put a game into or create into a game that they can learn that way. [T_B:I]*

Another class of hands-on activities used was ***open investigation*** activities. These were thought to be both interesting and valuable for learning. For example, in developing ideas of area and perimeter, and extending this to optimisation, one teacher used a four metre long piece of string. The investigation explored the relationship between area and perimeter, and was extended to volume. The students held it so that it looked like a metre square with an area of one square metre. Then the string was reshaped into a rectangle of approximately half a metre by one and a half metres. At first the children thought it still had the same area (since the perimeter was the same). "Until I went right down and put my finger in there, and [said], OK, that's about a centimetre. How many square centimetres along there? And they realised it of course. The area changed but the perimeter remained constant. They had to see it because they didn't believe it for a start" [T_D:I]. Carrying out the same process with a cubic metre was quicker, and "it's a good way of visualising a million too" [T_D:I]. T_D cautioned that, even though open investigation activities benefited both learning and interest, not all mathematics topics were suitable for this type of approach. Furthermore, this approach was sometimes more time-consuming than conventional teaching approaches.

Using ***equipment*** to demonstrate specific mathematical ideas also elicited interest from the students even without the use of an open investigation component. Teachers claimed that students were often more interested when they could see what was being talked or drawn or written about. One teacher gave details of a teaching episode using a container with plastic taps that students found interesting. Students were able to check their volume calculations on actual cylinders using Archimedes' principle. The correspondence between what was being calculated and what the equipment corroborated appeared to be what was interesting to students.

> *Well they had worked something out mathematically on paper but they saw that it worked approximately out physically. They have actually proved what they have calculated, give or take a few millilitres. [T_D:I]*

This 'seeing is believing is interesting' principle also held for more abstract parts of the curriculum. Referring to algebra, teacher T_D noted that his students appeared to be more interested than in previous years.

> *The patterns and relationships that could be sort of physical because of match sticks and that sort of thing and drawing lines. It was pretty much paper work in previous years and I found that they didn't like it so much. [T_D:I]*

Making and drawing things was another source of interest to students that was used by teachers in their teaching.

- *We made reindeers and santas, an origami thing and then we made pop up cards for measuring and stuff. We made geometry shapes and made them into mobiles and stuff.* [T_E:I]
- *Anything where they make something. Like with 3-D polyhedra, making nets. They made models of the shapes, like prisms and tetrahedra. They made nets for shapes. ... They did scale drawings and side views, front views and isometric drawings from link cubes, making shapes and drawing them from each others. They love that. In fact I couldn't move them off it.* [T_B:I]
- *They are going to find that making the shapes is a whole lot more fun than reading about all these different names that you seem to put to different shapes.* [T_C:I]

Teachers had a variety of reasons for using hands-on activities for interest in their mathematics classrooms. Hands-on activities were sometimes used as an interesting way of teaching and learning mathematical concepts, and at other times for stimulating student interest at the start of a session, or as a reward, or a way to finish off a lesson, and as a more interesting way of assessing a unit of work.

Student Trust activities

Student trust activities are activities in which students share ideas through dialogue, have choices, and use their own creativity. For teachers this includes welcoming student contributions, and letting students make their own decisions about content, time to complete, and type of activity. While all the teachers thought that students found this type of activity interesting, they reported using this type of activity only sometimes (one hardly ever).

Examples of student trust activities included: getting students to teach other students, statistical investigations, designing games and using the students' designs in class, students planning and running the maintenance section of the lesson, using 'go and find out' activities, and giving students choice about what to do and when to do it for assessments. Student choice of activity was also used and seen as a way of allowing students to follow their own individual interests.

One specific version of student trust was referred to by teacher T_B as *jigsaw* teaching, where the teacher and students got together and discussed the achievement objectives at the start of a unit of work. The teacher then taught one person from each group in the class, and this person then taught the others in groups in their own time. Assessment involved a written report on what they had learned and a self-assessment.

> *We did Algebra and I thought that's my pet hate and I thought what can I do that's a bit different so we did jigsaw teaching. I taught one person from each group. We took an objective and they went away and taught each other in the group and then they wrote reports on themselves and each other and they just loved it. [T_B:I]*

Finding out what students already knew about a new unit of work provided another student trust activity. Instead of the conventional pre-test for the next unit of work students either brainstormed what they had previously mastered or gave a self-rating for the achievement objectives in the new section.

> *At the beginning of a unit we look at what the objectives are and we either do one of two things. We'll either do a brainstorm of what we already know, so what are we going to do from here? Or they do a self-rating like they say, "yes, I know what this one is" so we don't need to cover that. Or, "I've got no idea what this one means" so we need to spend some more time on that. [T_B:I]*

Using a variety of activities

One way that teachers in Zahorik's 1996 study suggested to increase interest within their classrooms was to vary the activities in classes both within a lesson and across a series of lessons. In the responses to the questionnaires from the five teachers in the study, one teacher thought that students found using a variety of activities very interesting, three teachers thought students found it interesting, and one thought that students were neutral insofar as interest was concerned when using varied activities.

The one teacher who did not think students found the use of a variety of activities interesting suggested that the students needed consistency, that "too much change is difficult" for them [T_A:Q]. The teacher who answered "very interesting" achieved variety "by creating routines in which variety is easily incorporated" [T_C:Q]. Despite contrasting beliefs about the value of using a variety of activities in their classrooms, both teachers clearly value maintaining a routine system of classroom management. One possible explanation of this difference is that the way in which each of these teachers maintained their classroom routine was dependent on their own belief related to the value of interesting their students. Believing variety to be interesting was associated with routinely having a variety of activities, whereas believing variety not to be particularly interesting was not.

All teachers in the study did however report using variety for interest at least sometimes. One way of providing a variety of activities included setting up three or more activities in a lesson, with groups rotating between activities. Some teachers routines included using various activities such as board work, mat work, bookwork, games, investigations, competitions, tests and other forms of assessment within a lesson. One teacher suggested that "even just 20 questions" and "bookwork, since it's a novelty in my class" were interesting to students [T_C:FG].

Open investigation learning was seen as being interesting ("kids very involved in what they were doing – hard to stop" [T_B:J] when referring to an open investigation lesson related to whether specific games were fair or not). Teachers commented that interest levels increase when students are able to make connections for themselves:

> *Those that came up with the factor multiplication idea were very proud of themselves" [T_B:J].*

Tests were considered to be sometimes interesting, for some students, and sometimes not. One teacher who published results of tests along with running averages and current position in class thought that the children were "very interested in their averages and positions" [T_D:I]. T_D thought that there were both motivational and feedback components to the interest generated by this tactic – but that not all students found the comparative set of results interesting. (Comparisons were made with others in the class on the current test, with each student's previous check out tests, with their running average, and also with groups from previous years).

Students in this school took part in three external mathematics competitions – the New South Wales Mathematics Competition, the Otago University Problem Solving Challenge, and the local interschool 'Mathletics'. While only some of those in the two top stream classes (one in Year 7 and one in Year 8) were able to participate in these outside competitions, there was a taste of this for other students. This school ran its own internal Mathletics competition, and also a speed-at-tables competition, in which all students took part. The teacher of the top stream classes, who is also the instigator of the internal competitions, commented that, "most children really enjoy the challenge [of these activities] and look forward to the certification from their final results".

Group activities

Group activities involve at least two students in developmental, assessment, or skills based tasks, and may involve elements of student trust. All the teachers in the study thought that students found group activities interesting. Teachers regularly incorporated group activities, although off-task behaviour by some students working in groups posed classroom management difficulties for some teachers meant that group work was not done more often. Group activities mentioned by the teacher participants included: statistics investigations, designing and playing games, partner tests, "go-and-find-outs" [T_C:Q] where students are given a task and need to go outside the classroom (for example, to the library) to complete the task, competitions, cooperative problem-solving, jigsaw groups – "where each person learns/does a part of the whole and they have to come together with their information to solve the problem" [T_B:Q], and simply 'discussion'.

5.4 Teacher Factors Used to Promote Interest

Teacher Enthusiasm

Personal behaviour modelled by the teacher was thought by teachers to be a significant factor in supporting or generating interest in the task or lesson. Examples of teacher enthusiasm include using humour, describing personal experiences, being excited or enthusiastic, and joining in as an equal member of a group. All teachers thought these factors helped make mathematics either very interesting or interesting for students, and said that they used teacher enthusiasm either sometimes or a lot. One teacher described "telling a daily joke – especially mathematical ones" [T_D:Q] as one of the ways of projecting teacher enthusiasm. Humour was also injected into teaching sessions in the form of anecdotes or stories related to the mathematics to be taught.

> *... like Archimedes hopping in the bath and all that sort of thing so they just get those little bits and pieces as well. Actually some of them are ones the kids come up with, like the angle one that the kids came up with one year, three years ago. They're sitting there like this [teacher gestures], with their arms and I said, "what are you doing?". They said, "trying to remember the angle like if you poke someone that's with a sharp elbow isn't it? That's acute because it's a sharp pain." So I use that now because they actually came up with it. [T_B:I]*

Teachers demonstrated enthusiasm by "providing interesting bits of information—history of mathematics (my class respond really positively to this)" [T_A:Q], "playing games with the groups" [T_B:Q], using funny stories to help students remember the meaning of words (as above), class yarns, and "working out my bike race speeds and distances" [T_D:Q]. A specific way of creating interest using teacher enthusiasm was pitting teacher wits against the students.

- *I like teaching all the units, some I find better than others. It might be quite unusual – I quite like teaching algebra because I've got some real smarties in my class. You always will have kids that are far more intelligent than yourself and they always try and be quicker than you. Like [student's name] trying to show that you've made a mistake. But algebra's something completely new to them. [T_D:I]*
- *There are about three of them [students] that try to beat me all the time. [T_A:I]*

Teachers generally realised the power of being enthusiastic while teaching for generating interest.

- *I think it all comes down to the fact I think the teacher is the greatest actor and if you can act as if it's exciting the kids are going to love it; if you make it out to be boring the kids are going to find it boring ... [T_C:I].*
- *Yes, they've got to see somebody really into it. If I come in and say "we are going to do this activity. Turn to page whatever" they get nothing out of them. ... If I come in and [say] "I've got this cool activity today" they all respond. So my class respond to whatever enthusiasm I bring to it. ... Lucky I like mathematics. [T_A:I].*

Being a participant in this study also had an effect on teacher enthusiasm. The flowing comment was made about teaching a unit of work on probability.

> *They really enjoyed the hands-on things, the actual rolling a dice and the counting. I think it was probably also because I'm doing this [taking part in the study] I'm actually making a concerted effort with all the curriculum areas. [T_C:I]*

Relating content to a student's individual interest or knowledge

On some occasions the teacher develops the mathematics content around the prior knowledge of students, using either the individual interests of the students or topical situations. Three of the teachers thought that students find these activities interesting, one neither interesting nor boring, and the other offered no comment. When these activities were used it was usually for topical events such as the Olympic Games, the Census, or school events such as athletic sports or other sports results.

> *This age group are usually interested in sport so if I can link to sport like doing length and area instead of saying a farm you'd say a rugby field. I find things that they are interested in. Like how many padder tennis courts get into a soccer field. [T_C:I]*

All teachers in the group encouraged students to use their individual interests as the basis for the statistics investigation undertaken by all students.

Teachers also reported awareness of the global interests of students at this age and suggested sports, popular music, celebrities, and TV as suitable areas that could be used as contexts for mathematics. A special form of these global interests is that students find *themselves* interesting [T_C:FG], so classroom activities that can be related to the students themselves are essentially interesting to students.

One teacher, T_B, used a system whereby at the start of each unit of work the students brainstormed what they knew already, and discussed the curriculum objectives to be covered in the forthcoming unit, hence aiming to build the learning on points of each student's prior knowledge.

Using a variety of resources: novelty and intrigue

Using a variety of resources refers to using materials not frequently used, and could include field trips, mathematics competitions, dice, or even different texts. To the extent that some of these materials may involve hands-on work, or using novel resources may imply using a variety of activities, there is some overlap with these classes of activities. Teachers thought that these activities would be interesting or very interesting for students, and all but two reported regular use of 'different' materials. Art, dice games and board games, using Science equipment for measurement, mirrors, computers, calculators (not mentioned often), link cubes, and pairs of compasses were mentioned here. The outside measurement activities in the hands-on section can also be included here, as can the sundial and sand clocks activities mentioned earlier. One teacher, [T_D:FG], mentioned using a variety of texts that experience had shown contained sections with especially good teaching material, while another [T_C:Q], mentioned visiting other classes – an internal field trip. Most of the teacher participants (T_B, T_C, T_A, T_E) used food – cakes, lollies, chocolate bars, pebbles – as a resource for teaching probability and fractions. They reported increased student interest levels when lessons involved food.

> *We had uncooked caramel roll – cut into 14ths. There were two rolls. [28 in class]. Huge hit with class. [T_A:J]*

Teachers felt that students appeared especially interested when ideas or activities were new or intriguing.

- *Problem solving. Did a brainteaser sheet. E.g. you have 55c in two coins. One of them is not a 50c. What are the coins? All children thoroughly enjoyed this sheet. [T_A:J]*
- *[Murphy's Law] It's on the NZ maths site, Maths On line. It's just fantastic. I've really got my boys into that one. [T_A:I]*

The lure of open investigation approaches may be partly due to this intrigue factor. Comments from teachers included:

- *Kids found this interesting and fun because they learnt something new – they found this [use of the constant key on a calculator for repeated operations] surprising. [T_D:J].*
- *Children were surprised at the size of a cubic metre and the number of cubic centimetres in one cubic metre. [T_D:J]*

Practical activities

Practical activities are those that have some real world relevance. Making things in mathematics that can be used outside the classroom (as a gift or other) and finding out about compound interest are included here. One of the teachers thought that students found these activities neutral insofar as interest is concerned, while all the others thought students found them either interesting or very interesting. Activities quoted ranged from doing a real world maths assignment, making fold-up cards, three-dimensional models and origami trinket boxes for gifts, using calculators for compound interest and GST, and developing the practical skills for measuring areas and volumes for painting and landscaping tasks.

- *We did a 'Real World' Maths assignment – a real winner with the class. [T_A:Q]*
- *Ordering concrete for a path. Working out the circumference for the athletics track. [T_D:Q]*

An episode from the teacher focus group discussion confirmed the interest in a practical activity that two teachers had used:

T_D *Finding pi by rolling a wheel and dividing by the diameter. And going out and making a circle of 20 metres in circumference.*

T_A *I did that with my kids and they loved it, they absolutely loved it. You know I was quite surprised.*

Using tasks of a suitable level

The first response of one of the teachers when asked about what made mathematics interesting for her students was "whether it gives *success*" [T_E: FG]. Zahorik (1996) noted that teachers felt that students are more interested and successful when they are able to follow instructions and questions, when the work is at a suitable level, and they are able to work at their own pace. Such tasks provide the right level of challenge so that students are not put off, but are also learning new ideas or consolidating previous ones. All the teachers in the study agreed that appropriate levels of challenge added interest or at least mitigated boredom.

If the work's too hard they are going to get bored. If the work's too easy they are going to get bored. But it's also good to have stuff that they know. [T_C:I]

One challenge to students to change the rules of a game in order to make it fair or unfair resulted in much student interest [T_B:I].

Teachers were asked how they managed to find suitable tasks. The most frequently mentioned approach to finding suitable tasks was to use a variety of text resources and choose those activities that experience showed were at the right level. Things that worked well (and things that didn't work well) were then added to the teacher's experience for choosing suitable tasks in future. One teacher suggested that the streamed classes made it easier to find suitable tasks, noting that there was still a wide ability range in the class. Using external and internal maths competitions provided challenges for the more able students. Several teachers also felt that for some students tests provided another source of positive challenge.

Activities with more than one interest factor

Many of the activities that classroom teachers use to provide interest for the students cannot be classified exclusively into one of the categories above. There is often a degree of overlap between the interest factors and a particular activity. For example, using a calculator for repeated calculations could be categorised as either hands-on (manipulating the calculator), using a variety of resources, novelty, or even, if the context was a real world one, as a practical activity. The mapping exercise described in the hands-on section could also be categorised as a student trust activity (using their own creativity) or using a variety of resources or activities.

One example of how more than one interest factor is part of an interesting teaching episode is notable because of the attitude of the teacher prior to teaching the unit of work.

> *We did algebra and I thought "that's my pet hate" and I thought "what can I do that's a bit different?" so we did jigsaw teaching. ... They loved it. It was on their own time and that as well too. [T_B:I]*

This example combines teacher enthusiasm (as a reaction to the teacher's initial lack of interest) with aspects of student trust (such as students teaching other students; using student choice) a novel teaching approach and possibly avoiding the boredom associated with a summative test (which was part of the teaching approach) – see the section below.

Increasing interest: decreasing the likelihood of boredom

One way to increase interest levels is to avoid those activities that are felt to be boring. The teachers in the present study believed that students were generally bored by *sedentary activities* (Zahorik, 1996), the converse of hands-on activities. Sedentary activities include sitting at their desks, doing bookwork and worksheets, and just listening to the teacher. Other examples of things that students did not find interesting (or found boring) included (the interesting converses follow in brackets): things they can't see, like abstract ideas (practical tasks); work which is not their own idea (student trust activities); mathematics not related to real life (practical tasks); getting poor marks or not being ready for a particular topic (suitable tasks); and an unenthusiastic teacher (teacher enthusiasm). In particular, all but one of the teachers thought that pre-tests for the next unit of work were very debilitating in terms of interest, even allowing for the interest generated by showing improvement from the pre-test to the unit test.

5.5 Mathematical Ideas Teachers Believe are Interesting to Students

Zahorik (1996) suggests, "Putting students into contact with inherently interesting *content* [researcher's italics] seems to be an important way to create interest in learning" (p. 557) but notes that this does not seem to be a high priority for teachers. When asked to write about interesting ideas, one third of the teachers in his study wrote exclusively about hands-on activities without mentioning content at all; and another half mentioned both content and hands-on activities together – without any separation of the two.

The questionnaire in this study aimed to make the separation between *mathematical content* and the teaching *activities* used to teach the content explicit, by asking what mathematical *ideas* their students found interesting and subsequently asking how the teachers could incorporate these interesting ideas into their mathematics classes. Even so, the teachers (and students) in this study had similar responses to those in Zahorik's study. Most responses centred on interesting activities rather than the ideas themselves being interesting. As was found in Zahorik's study, one teacher questioned whether some mathematical ideas and facts are interesting in themselves, saying, "I'm not so sure" [T_E:I]. Another responded, with: "I think they're [students] a bit young sometimes. A lot of things go over their heads" [T_B:I].

Those topics or ideas that were noted as being interesting to students, were *topics* that were taught using *activities* that students found interesting. For example, the topic *symmetry* was cited as being interesting to students, [T_E:Q], and this topic was taught using a variety of interesting (to some students) shapes such as kowhaiwhai patterns. It may have been the *making and drawing* activity used with these patterns, and the aesthetic appeal of the product that was interesting, rather than the topic itself. The following discourse from the teachers' focus group discussion relating to an activity related to the transformation *enlargement* highlights this idea.

T_D *They like doing those enlargements don't they?*

T_A *It doesn't seem like mathematics to some of them.*

T_C *It doesn't seem like mathematics to me!*

T_A *They say, "Ooh, we're doing art ..."*

Similarly, the citing of *most probability activities,* [T_C:Q], shows that the teacher is associating the interest with the dice-rolling and Beanz-using activities more so than the mathematical ideas involved. Other mathematical 'ideas' mentioned by teachers during this study that involved interaction between *content* and *activity* were 'Geometric shape construction' [T_C:Q], and 'problem-solving' [T_B:I], and 'Archimedes' principle' [T_A:Q].

However, there were some responses to this question that focussed on the mathematical ideas rather than activities. For each of the following topics at least one teacher suggested that students found the following ideas interesting: certain shapes will tessellate; the internal angle sum of a triangle is 180 degrees; there are "360 degrees in a circle"; the rules for divisibility of integers; the relationship between diameter, circumference and pi; one cubic decimetre holds one litre and when filled with water weighs one kilogram; Archimedes' principle; the Theorem of Pythagoras; different number systems, finding the rule for the general term in a sequence.

The converse of the idea that some mathematical ideas are interesting per se is that some are boring. Teachers were quite negative about some sections of the curriculum that they felt were boring for them and for their students. Mathematical topics that teachers in this study believe are not interesting, or are even downright boring to students, were algebra, fractions, things they can't see (abstract ideas), number, computation and angles.

- *Number is boring. It's boring. It really is. [T_B:FG]*
- *They don't like fractions, definitely don't like fractions. [T_E:FG]*

Teachers appeared to have a good idea of what mathematical content interested their students. Students found the curriculum sub-strands of probability, problem solving, geometry, and symmetry and transformations the most interesting (see Chapter 4), and teachers realised this about their students and also as a group found these areas more personally interesting. There may be a positive correlation between the students curriculum interests and those of the teachers, but as the sample of teachers was quite small no claims can be made about that. One teacher commented that the geometry strand (comprising the sub-strands of Geometry and Symmetry & Transformations) was generally interesting to students, and that he made use of this interest in his teaching.

> *Geometry appeals. I plan my work so that I intersperse it throughout the year. [T_D:I]*

5.6 Creating an Environment that Supports Student Interest

There were several suggestions in the literature and also from the student and teacher focus groups for creating an interesting learning environment.

Bergin (1999, p. 90) suggests that "feelings of happiness or euphoria during a task are likely to foster interest when the task is reencountered", and contrasts this with negative feelings causing avoidance. Following up this idea with the teacher participants was done by asking what teachers did to ensure that their students had *positive feelings* and to decrease negative emotions in their mathematics classes. One of the teachers in this study suggested that the groups he taught had positive feelings towards learning mathematics most of the time. The others all stressed that they helped their students remain positive by making sure that they had success often—improvement was the essential thing rather than total success—and that failure at certain things was something to use positively for their development.

> *To start off with I always give them success. I always take it down to the very basics and get all excited because they are getting it right. [T_E:I]*

This was combined with positive reinforcement—"that's cool mate. You're onto it, rah rah rah rah" and "You're a super star" [T_E:I]. Other ways of making students feel good mentioned were: spending one on one time with the students, starting with a game, encouragement to work and learn in groups, making it easy to ask questions, and encouraging independence. Putting students on the spot was cited as a way of making students feel bad, and hence was to be avoided.

Some of the students in the focus groups suggested that aspects of the physical *classroom environment* had an effect on their interest levels. The most frequent response from teachers about having an interesting classroom environment was to have student displays of work. Other responses were: grouping students, having music playing quietly in the background, maintaining a colourful environment, having games on hand and problems to solve on the wall (if the students so choose).

Middleton (1995, p. 254) suggests that "designing intrinsically motivating activities is of paramount importance in developing lifelong learners", and then goes on to equate intrinsic motivation and fun. Teachers were asked how the went about *making mathematics fun*. Being enthusiastic, teaching in a relevant (to students) context, and using hands-on activities were the most common approaches reported by the teacher participants in this study. Other ideas included using personal experiences, using unusual ideas or approaches, putting mathematics in a real world context, using open investigation approaches, and working in groups. A note of caution was sounded by one teacher who suggested that "it can't all be fun – there is an important place for exercises and consolidation" [T_D:Q].

Teachers were asked two general questions in the questionnaire. The first of these was about how they *made mathematics interesting for students*. One teacher summed it up by saying: "Keep up my enthusiasm, be well organised and planned – seek out resources that are hands-on for activities and consolidation. Let children have more input, relate it to a meaningful context, see how the concept is used in the outside world" [T_E:Q]. Others generally commented on using a variety of activities, resources, and teaching strategies; using practical exercises; using group work; giving students the opportunity to make their own choices; using hands-on activities (especially including games); and doing more research of their own on a topic. One teacher, [T_C:Q], suggested being enthusiastic. And one teacher, [T_D:Q], commented that time is limited – so teachers do their best to make mathematics interesting, but the available time and resources and school structures to do this do have real constraints.

The teachers in this study also mentioned avoiding taking actions that appear to bore students, thus avoiding those ideas mentioned in the last part of section 5.2.

5.7 Overview

The teachers in this study all placed a lot of importance on making their mathematics teaching interesting. They interested their students in several ways: using hands-on activities, a variety of teaching approaches and resources, student trust, group work, content related to individual knowledge and to the outside world, teacher enthusiasm, and novel and intriguing tasks, aimed at a level that was challenging yet accomplishable. Often teaching practice used a combination of these features. Furthermore, actions were taken by these teachers to avoid activities that either bore students or at the very least are not interesting. Teachers noted few mathematics ideas or topics that were inherently interesting. As well as using the activities noted above they did try to make mathematics more interesting to their students by encouraging the students to have positive emotions related to mathematics and making the mathematics classroom an interesting and fun environment.

Chapter 6: Discussion and Conclusion

6.1 Introduction

This study investigated interest in intermediate school mathematics classrooms with the aim of providing a rich description of the use and development of interest in these effects and extent of interest in this setting. A secondary focus was on teacher views of both what they thought students found interesting and their actions relating to interest in school mathematics classrooms.

This chapter begins by reviewing what it means to be interested in something. The role of interest in intermediate school mathematics classrooms is then examined and important features of interest, and its converse, boredom, are discussed. Implications of this study and suggestions for further research follow. The conclusions from the study complete this chapter.

6.2 The Role of Interest in Mathematics Classrooms

This study about interest in learning mathematics has highlighted some difficulties relating to how the words 'interest' and 'interesting' are used. Within the literature on interest researchers debate the precise meaning of these words (Freeman, McPhail, & Berndt, 2002) and identify different types of interest—typically individual interest, situational interest, and occasionally others such as topic interest (Ainley, Hidi, & Berndorff, 2002) and vocational interest and text-based interest (Boekaerts & Boscolo, 2002). Rather than attempting to educate the participants as to the precise definition of interest to be used, or operationalizing this definition, this researcher has explicitly used the words 'interest' and 'interesting' with participants throughout the study, and has taken the view that while students, teachers and researchers have different constructions of these words the range of data collection strategies used in the study enabled participants to engage in productive discussion about 'interest'.

Engendering, developing and maintaining interest in mathematics classrooms were all considered to be important by the teacher participants in this study. Interest was one of the foremost factors used in planning and developing lessons, activities, resources and sometimes even assessments. Most students reiterated the high value placed on interest by teachers. Commonly held beliefs of students were that interest was positively associated with the amount of time spent on task, increased concentration, better understanding and success in mathematics, better job prospects, and simply feeling better about participation in mathematical activities. Evidence from the literature suggests that these beliefs may be widespread, although the relationships between these factors appear to be complex, and to vary individually.

'Fun' and 'interest' are synonymous to some; to others they are simply highly positively correlated. Students generally wanted to be interested in their mathematics work, to have fun in mathematics classrooms, and they did not want to be bored. But there was a serious side to their need for interest and fun—they wanted to learn as well. Many students reported that games were interesting and this was especially so when they were clear that the games were for a mathematical purpose. Similarly, working in groups and being able to talk to friends made mathematics more interesting, not just because of social interaction, but also because the discussions enabled ideas to be clarified and learning to occur.

6.3 Features of Interest in Mathematics Classrooms

Despite lack of support for the claim that mathematics is inherently interesting, it was encouraging that both teachers and students were able to offer suggestions for enhancing interest levels. Both students and teachers suggested that hands-on activities (games, using manipulatives, making and drawing, moving around, using food), having a positive classroom where students were making progress, having an enthusiastic teacher, and having social contact during mathematics lessons made mathematics more interesting. Furthermore, many students suggested that they were more interested when they could understand and make sense of the mathematics that they were being taught. Conversely students were bored when these interesting aspects were absent, and they were especially bored when doing sedentary activities (e.g., bookwork). A summary of the most notable features of interest in mathematics classrooms follows.

Mathematical content versus mathematical activities

When students and teachers were asked what makes maths interesting they almost invariably mentioned mathematical *activities* and not mathematical *content*. This occurred even when they were specifically pressed to give examples of interesting mathematical content. Zahorik found a similar result with the teachers in his 1996 study. When asked to write specifically about content in relation to interest, fewer than 20% of the teachers in his study replied with content-only responses. The remaining 80% included references to activities, either wholly or in part.

One possible explanation of these results is that there may be a paucity of interesting material in the mathematics curriculum. However, this theory is negated by the reports from some students and teachers of a variety of mathematical ideas that are indeed interesting to both teachers and students alike. Another possible cause of the lack of use of content in developing interest is that teachers may not be aware of the possibilities and consequences of this course of action. Developing interest using mathematical content may be another level of mathematics teaching, which requires an awareness of the possibilities of extending further the 'catch' of the situational interest currently being generated, a theoretical foundation on which to base choices in planning classes, and some practice at developing these skills.

The students in this study almost universally endorsed hands-on activities as interesting, with games as the most frequently mentioned hands-on activity. The teachers had also noted that they frequently used hands-on activities to add interest to their teaching. For the most part reported use of hands-on activities in mathematics classrooms appear to be supportive of active mathematical learning. For example, measuring the circumference and diameter of a variety of "large" circles that led to the relationship between the circumference, the diameter, and pi. This use of hands-on activities appears to have prospects of developing an interest in other mathematical relationships, and further in mathematical content in general, in accord with Krapp's (2002) theory of developing interest to an individual stage. There was some reference to activities that appear to be ends in themselves, e.g. Buzz and even the 24 game. Students generally found hands-on activities interesting, and frequently added a preference for activities that were obviously relevant to the mathematics curriculum.

While it was disappointing that there was limited evidence of mathematical content being used to promote interest (some students and teachers in the study could think of no interesting mathematics ideas) it was notable that many students suggested mathematical ideas and topics that they found interesting. Students proffered a wide variety of specific mathematical ideas that they found interesting, ranging from *estimating from sampling* to *area and circumference of a circle* to *enlargements*. This suggests that there is room for development of this form of interest enhancement. When asked to rate the level of interest in the sub-strands of the curriculum, both students and teachers had similar patterns of ratings. They rated *probability, problem solving, symmetry and transformations* and *geometry* ahead of the other topics; and they rated *number* and *measuring time*, along with *all of mathematics*, as being the least interesting.

The content areas with the highest interest ratings were the ones that most frequently had interesting activities associated with them. Many students related their interest in mathematical ideas to the activities, materials and interpersonal experiences that occurred in their mathematics classrooms. While there may have been some confusion between mathematical activities and mathematical content, it does appear as though the stimulation of using situational interest factors may have left a more lasting impression and helped the content appear to be more intrinsically interesting.

Student progress

Both teachers and students reported that creating a learning environment that engendered success and associated positive affect was directly linked with interest levels. Teachers aimed to provide ways for this success to occur. For teachers, grades were the predominant measure of student success. While some students expressed the idea that good mathematics grades had a positive effect on interest others reported being more interested when they had more 'control', and getting good marks was not the only way of measuring this control. Students wanted to be clear about what they were doing, and why they were being asked to do it. They wanted to make their own choices (about pace, content and method) wherever possible. And they generally found it more interesting when they felt they understood the mathematics being taught. Good marks were just one aspect of a broad desire to make progress, and, according to the students, making progress and interest are positively associated.

Working in groups

The three factors most supported by students for making mathematics interesting were teacher enthusiasm, hands-on activities, and working in groups. Most students preferred working in twos or threes, with friends. There were some students (about 10% of those who responded) who found it more interesting working individually and some who stated a strong preference for this mode of learning.

Many students acknowledged the problems of working in groups: social interactions and other off-task behaviour (and the noise associated with it), some group members not contributing as much as others, and spending time on maintaining the group dynamics. However, students generally thought that working in groups was more interesting. The rationale most frequently used by students in support of this improved interest was that they could discuss difficulties as they arose, and help each other, and hence make better progress than if they were working by themselves. These reasons are among those advanced by Johnson & Johnson (1990) for using *cooperative groups* for learning mathematics. Students thought that all these features added to the interest in learning mathematics.

The teacher

The effect that a teacher has on student interest appears to be underrated by teachers. Teachers in this study consciously aimed to be enthusiastic about teaching mathematics, but did not see this as a trump card. On the other hand the students viewed teacher enthusiasm as one of the most important factors for developing and maintaining interest in mathematics classrooms.

The students wanted teachers to behave in certain ways to develop interest in learning mathematics and to reduce boredom as well. And they felt that teachers had the power to make mathematics more interesting or less interesting for them. Most students thought that mathematics was more interesting when teachers showed strong and positive emotions regarding mathematics learning; chose fun activities; treated students with respect; gave clear instructions; and made appropriate personal disclosures.

On the other hand teacher insipidity and negativity are features that reduce interest in learning mathematics. Perhaps there is nothing new in this, but teachers may not have previously appreciated the overwhelming show of support by students for teachers to be enthusiastic, and not insipid or negative.

Gender differences were apparent within the issue of enthusiasm. Although both boys and girls generally affirmed teacher enthusiasm and its relationship to increasing interest in learning mathematics, girls were significantly stronger than boys in their support of teacher enthusiasm for this purpose.

A variety of new related mathematics activities outside the classroom

After hands-on activities, group work, and having an enthusiastic teacher the three next most interesting types of mathematics classes were those that involved mathematics that was new, related to the students' prior knowledge (often of things outside the mathematics classroom), used a variety of activities, and where the students went outside the classroom. Some activities combined all these types of activity. For example, taking a class outside to measure the padder tennis courts, or to measure the grass temperature on a frosty morning.

Individual interests

Articles in the research literature related to interest in classrooms suggest ways in which individual interest can be used to develop learning (Bergin, 1999; Hoffmann, 2002; Krapp, 1999; Renninger, 2000). Zahorik (1996) refers to the teachers in his study using personalized content to increase interest for students. The students in this study did not rate this type of activity very highly, although they did find the chance to use their individual interests in the statistic project interesting. One possible reason for this lack may have been that many students were not exposed to using personalized content in mathematics classes. Responses in the teacher questionnaire showed that only one teacher appeared to regularly use personalized content in teaching mathematics. Students' individual interests appeared to be overlooked in delivery of the mathematics curriculum.

Students' views vary

Up until now the discussion has centred on classroom mathematics in which there appears to be a definite trend as to student opinion with respect to interest. Not all students think the same about what interests them in mathematics classes. Any one individual student may have quite different views as to what makes mathematics interesting to them. Furthermore, there were some types of activity where student opinion on interest was quite strongly polarised, and the greatest polarisation occurred where the level of difficulty was an issue. Students were either interested or bored by the relatively taxing external mathematics competitions, and mathematics that was easy or challenging also had mixed support.

6.4 When Mathematics is Boring

This study focussed on what students find interesting, and the actions that teachers can take to increase interest in learning mathematics. This was prompted by the researcher's own experience of teaching mathematics; while some students find mathematics fascinating many report the learning of mathematics to be boring and irrelevant. When replying to the question "What do you do for a living?" with "I teach mathematics and statistics", this researcher has usually been greeted either with glee and the comment "Mathematics was my favourite subject at school", or alternatively with a dull expression and rapid termination of the conversation by the questioner! Why is there such polarisation in the responses, especially when young children rate mathematics highly?

On the positive side this study suggests that in general intermediate school students are interested when they are active, having fun and interacting socially, have an enthusiastic teacher and when they believe that they are making progress. What makes mathematics boring to students at intermediate school is the reverse of all the above factors, and when these factors are not present, interest dissipates. Using textbooks and worksheets often or for long periods of time, lengthy periods of teacher exposition, working individually, having a teacher who is lacking in enthusiasm, and feeling that mathematics classes are aimless and pointless are all factors that increase boredom.

6.5 Implications

Don't drop the ball

Mathematics topics that students find most interesting are those that are taught in an interesting way. Teachers often do this by using the 'catch' part of the 'catch and hold' model of situational interest (Mitchell, 1993) in mathematics classrooms, using one or more situational interest factors. Teachers will catch more student interest if they use more than one interest factor at a time, as different students find different factors interesting. It follows that lessons ought to be planned to contain as many interest factors as possible, thus increasing the chance of catching the interest of all students in a class.

The next step is to develop the 'hold' part of Mitchell's model by maintaining this interest, possibly until it becomes topic interest, or even individual interest. This appeals as a more efficient practice in the long run, and one that has the potential to be perpetually fruitful. Topic and individual interests, once developed, are longer-lasting and can be used without recourse to the more ephemeral catch phase of situational interest.

Precisely what else is needed to develop the 'hold' aspects needs further investigation. Mitchell (1993) suggests the general principles of *meaningfulness* and *involvement* for this purpose. Furthermore, research into developing self-regulated and metacognitive behaviours (Pintrich, 2002; Zimmerman, 2002) suggests that making the interest factors overt may provide some insights into how the 'hold' processes could be stimulated. Another suggestion to 'hold' the student interest that has been caught is to explicitly link the situational interest processes used in mathematics classrooms to each student's progress. Students develop interest, with all the benefits that that implies, when they are clear about what they are doing and sure that they are making progress.

Teachers should also be aware of the dangers of using the 'catch' type of situational interest factors without planning to develop the interest so generated. Wrapping 'juicy' situational factors around supposedly 'dry' mathematical content may have two unwanted effects. One is that this practice appears to offer implicit evidence that the mathematics itself is *not* interesting (why else would the situational factors be needed?). The other is that exogenous situational interest embellishment has the potential to have a similar effect as *seductive details* (Wade, Schraw, Buxton & Hayes, 1993; Wade, Alexander, Schraw & Kulikowich, 1995; Harp & Mayer, 1998), by distracting students from the learning objectives. The danger is that in some cases the situational interest might overshadow the mathematics. For example, students may have said how tasty the chocolate rolls in a mathematics class were, without caring or even noticing what mathematical point was being made.

On a more positive note, there were several occasions within the study where students' expressed desire to make progress in mathematics was related to an awareness of the need to focus on the mathematical content, after the initial use of situational catch factors. Such beliefs have the potential to contradict the assumption that mathematics is boring, militate against the seductive detail effect, and improve the chances of holding interest, at least for some students.

There is a connection between all the implications above. It is *mathematical content and ideas*—mathematics itself. Mathematics teaching is likely to be more meaningful and involving (Mitchell's (1993) hold factors) if the catch factors that teachers regularly use are explicitly linked to the mathematics curriculum and reinforced in aspects of each student's world in which that mathematics is applicable, and if student progress is based on the mathematical content that is being understood and used. Furthermore, the seductive effect of exciting situational interest catch factors is likely to be reduced when their use is openly linked to the mathematics to be learned.

Teachers need to develop the skills to ensure that once students have caught the (interest) ball, they hold onto it, and don't drop it.

Use the influence of others

Teachers appear to under-rate the effect of teacher enthusiasm on interest in learning mathematics, at least in comparison to students, especially female students. Yet teacher enthusiasm may be used to develop interest even when other situational factors have no obvious application. Furthermore, ultimately linking this teacher enthusiasm to the mathematical content taught is potentially doubly beneficial: students often learn more by focussing on the interest in the content, and this in turn may engender more interest.

Most students find mathematics more interesting when they are working in groups—pairs or threes being the most preferred. They enjoy the social interaction, both for gratuitous reasons and also because they are able to discuss the work to be done. But not all students wanted to work in groups. Thus teaching should allow for such flexibility, varying involvement from solo to groups of up to 3 students. Admittedly teachers need to reconcile the possibly competing needs of interest, progress and control within their classrooms. Alternatively teachers could develop cooperative learning approaches that use the benefits of group work in a structured way (see Davidson (1990) for further details).

6.6 Further Research

The results of this study provide a basis for the following ideas that are suggested for further research.

1. Teachers and students alike appreciated the need to make mathematics interesting. Students in this study all had some interesting experiences in their mathematics classrooms. Yet the interest rating for mathematics as a whole was lower than most of the individual topic ratings. Research is needed into why mathematics as a subject is rated so low, when students consistently rank parts of mathematics as interesting. How can mathematics educators and teachers help students to transfer the interest from specific mathematical experiences to mathematics generally?

2. A focus on interesting and fun activities in mathematics classrooms in order to catch student interest was evident in this study. The examination of how such situations develop the hold part of situational interest after the interest has been caught is needed. This examination will inevitably centre on the relationship between the interest generated in a mathematics class and the mathematical content being taught—how effective is teaching that uses the interest in activities and materials, and then takes the extra step of focussing this interest on the mathematical ideas to be taught.

3. Research on metacognition notes that having students keep a record of aspects of their learning often prompts an improvement in functioning (Zimmerman, 2002). Does raising awareness and developing knowledge about one's own interests, in essence improving 'meta-interest', support the development of student interest parallel to the way improving metacognition operates for

cognition? If so, how can self-regulatory processes with respect to interest be taught?

4. Individual interests are long-lasting, yet by their individual nature teachers find them difficult to harness effectively in classroom teaching. How can mathematics teaching more effectively utilise individual interests?

5. While both students and teachers were of the opinion that interest and learning were positively correlated, knowledge of the effects of interest and what the factors of situational interest are appears to be developed in an ad hoc manner. That many teachers believe that encouraging students to be interested is important, and that much effort is put into this aspect of teaching, suggests that an understanding of the educational theory and practice of interest in classrooms is needed. Research should be conducted into how to increase teachers' awareness of the role of interest in learning mathematics, and to develop their skills and knowledge in this area.

6. The interest level that students have for certain activities and topics is part of their educational profile, and appears to have an effect on the quality of a student's learning. A method of measuring, monitoring and recording interest levels of students and/or classes might provide useful data for teachers. This could then be used to determine approximate measures of interest for activities, materials, and systems of teaching used in mathematics classrooms. Research detailing these results would be a useful resource to teachers.

7. Students in this study generally railed at doing bookwork and using worksheets and textbooks for learning mathematics, but there were some who found interest in specific worksheets. Which texts and worksheets that are commercially produced, or are available over the World Wide Web, enhance interest in learning mathematics, and which have the opposite effect, would be a worthwhile area of investigation. Likewise an investigation into the interest levels associated with commonly used resource and materials in mathematics classrooms would be useful.

8. Much of chapter 2 was derived from studies that involved curriculum areas other than mathematics. A special argument was made for using mathematics as the initial curriculum area in which to study classroom interest. Research into using interest in other curriculum areas is suggested.

6.7 Conclusion

This research study used qualitative approaches—namely, focus groups, questionnaires, journals and interviews to find out about the use and development of student interest in mathematics classrooms. A sample of 102 students from six classes at a New Zealand public co-educational intermediate school and five teachers from this school participated in the study.

The findings of this study add to our knowledge related to what students find interesting in mathematics classrooms and to how student interest is fostered, used, maintained and developed in these classrooms. The results show how teachers use perceived student interests within their teaching practice, what students find interesting, and the values and beliefs that these two groups have regarding mathematics classrooms being interesting places in which to learn. The study details the proliferation of interest-inducing devices used by teachers in their mathematics classes, and the effects that these have on students' mathematics learning and developing interests. Specifically highlighted in this study is that while many interesting activities are used in intermediate school mathematics classes mathematical content in itself is not viewed as inherently interesting for students.

Students in the study generally wanted to be interested in mathematics. While they enjoyed the interesting activities, they often reported the interest to be tied to the mathematics learning that was furthered by the interesting games or group work. A key factor that reinforces the need to provide instruction that develops students' personal sense-making of mathematics was students' reported view that interest levels increase when they understand. All this suggests that the factors that interest students at this level should in practice be explicitly linked to the mathematics content to be taught, and students encouraged to find deeper interest in the mathematical material itself, either in the mathematical ideas or in the practical uses of this content.

Teachers can make their lessons more interesting (while being no less instructive) if they take cognizance of the student interest factors mentioned in this study. This can be done by teachers using a variety of hands-on activities, especially games, making and drawing activities, manipulative equipment that illustrates mathematical ideas, and food; group work, especially employing cooperative approaches; teacher enthusiasm, which may need developing in the first place by finding something to enthuse about; mathematics that is suitable in level and context, for example using practical or personalized tasks that are at least occasionally challenging; and maintaining a positive atmosphere that emphasizes student trust and student progress aspects by keeping the students realistically informed and valuing and using their mathematical contributions.

If teachers were able to organise classes with the above factors to the fore, and do less of what students find makes mathematics boring (sedentary activities such as writing, bookwork and listening to the teacher, using unsuitable tasks, being unenthusiastic, limiting student choice, using artificial tasks), then learning mathematics would be more interesting for most students.

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Appendix 1: Information sheet for teachers

<u>What makes Mathematics lessons interesting to students in the middle school</u>

INFORMATION SHEET

Kia ora.

My name is Evan Jones. I am a teacher at EIT Hawke's Bay, where I teach Mathematics and Statistics to engineers, business studies students, science and wine science students.

As part of my professional development at EIT, I am completing research for a thesis in Mathematics Education. I have always been fascinated by the light that shines in a student's eyes when they catch on to some interesting, to them, mathematical idea or skill. I would like to find out how to make this happen more often.

My research proposal is to complete a qualitative research study on how 'interest' is used by teachers in mathematics classrooms to develop mathematics teaching, what interests intermediate school students have that have potential use in the classroom, and how to foster interest in learning mathematics. An important reason for doing this study at an intermediate school, is that this is a time when students' attitudes to education crystallise. It would be good if as many students as possible could develop a positive attitude to learning mathematics.

I want to find out everything I can about what teachers believe is interesting, how they use interest to plan and deliver lessons, what students find interesting in a mathematics classroom, how some mathematics learning can be made more interesting, and more.

In order to do this, as well as reading lots about what interests students and what effect that has on their mathematics learning, I need to find out from real live teachers and students what they think about interest in mathematics classrooms. I would like to find out what teachers think is interesting, what do they do to foster that interest, and what effect does interest have on mathematics learning.

I need volunteers to be involved in this research. My strong hope (and belief) is that the volunteers will gain something from their participation. Participating in the study will involve the following commitment from teacher volunteers.

Activity	**Estimated time involved (maximum)**
Participation in a focus group discussion about interest in the mathematics classroom.	1.5 hours
Filling out a questionnaire based on the focus group above.	1 hour
Keeping a journal with respect to interest in the mathematics classroom for the remainder of term three.	4 hours
Individual interview based on journal	1 hour
[Group session with other teachers for development of teaching using interest.]	[2 hours]
Workshop to provide access to a summary of the findings of the study when it is concluded.	0.5 hours
Collection of student journals	1 hour
Total	**11 hours** (over 6 months)

All information gained by me during the course of this study will be used for the purpose of completing my thesis, and will be kept confidential, unless any participant permits such disclosure. References to individuals in the thesis will not enable others to identify any individual participant, nor will participants be able to be identified by any reports about this study. Confidentiality will be stressed in all focus groups as part of the group process. After the thesis has been written, all records kept for the purpose of completing the thesis will be destroyed (or returned to the appropriate participants, if requested).

Participation in all aspects of this study will be voluntary. All those who volunteer to participate in this study will still be able to decline to take part in any part of the study, or decline to answer any question put to them, or withdraw from the study at any time, or ask questions about the study at any time, without prejudice.

Appendix 2: Information sheet for students and guardians

What makes Mathematics lessons interesting to students in the middle school

INFORMATION SHEET

Kia ora.

My name is Evan Jones. I am a teacher at EIT Hawke's Bay, where I teach Mathematics and Statistics to engineers, business studies students, science and wine science students.

As part of my professional development at EIT, I am completing research for a thesis in Mathematics Education. My research is about how 'interest' is used by teachers in mathematics classrooms to develop mathematics teaching, what interests intermediate school students have that can be used in learning mathematics, and how to foster interest in mathematics learning in the classroom.

An important reason for doing this study at an intermediate school is that this is a time when students' attitudes to education crystallise. It would be good if as many students as possible could develop a positive attitude to learning mathematics.

I want to find out as much as I can about ***interest*** in learning and teaching mathematics. In order to do this, apart from reading lots about what interests students and what effect that has on their mathematics learning, I need to find out from real live teachers and students what they think about interest in mathematics classrooms.

I need student volunteers to be involved in this research. My strong hope (and belief) is that the volunteers will gain something from their participation.

I will ask for student volunteers to:

1. Take part in a group discussion (under 1 hour), of no more than eight students at a time.
2. Complete a questionnaire (taking under 1 hour) about interest in learning mathematics.

3. Keep an in-class journal of their thoughts about interest in mathematics (a few minutes in each mathematics class).
4. Have an individual interview (about half an hour) about interest in learning mathematics.

This is a commitment of six hours maximum over terms three and four.

Please note

I hope I get more students than I need for this study. If that is the case, it may be logistically difficult, or even impossible, for all volunteers to be part of one of the group discussions or to have an individual interview. If that is the case I will randomly select students to participate in these activities. I will inform all student volunteers in writing of their selection or non-selection for the various aspects of the study.

All information gained by me during the course of this study will be used for the purpose of completing my thesis, and will be kept confidential, unless any participant permits such disclosure. References to individuals in the thesis will not enable others to identify any individual participant, nor will participants be able to be identified by any reports about this study. Confidentiality will be stressed in all group discussions. After the thesis has been written, all records kept for the purpose of completing the thesis will be destroyed (or returned to the appropriate participants, if requested).

Participation in all aspects of this study will be voluntary. All those who volunteer to participate in this study will still be able to decline to take part in any part of the study, or decline to answer any question put to them, or withdraw from the study at any time, or ask questions about the study at any time, without prejudice.

Appendix 3: Focus group discussion points for students

1. **Things that students like about school in general and mathematics in particular.**
   Are there things about school in general that you like?
   Are there things about mathematics that you like?
   What makes being at school interesting to you?
   What makes mathematics interesting to you?

2. **Things that students dislike about school in general and mathematics in particular.**
   Are there things about school in general that you dislike?
   Are there things about mathematics that you dislike?
   What makes being at school boring to you?
   What makes mathematics boring to you?

3. **Mathematics content that students find interesting – or uninteresting**
   Talk about any mathematics ideas that you have found interesting.
   Talk about any times you have thought that mathematics was interesting.
   Similarly for uninteresting.

4. **Activities in mathematics that students find interesting – or uninteresting**
   What do you like doing most in your mathematics classes – either here or in previous classes?
   Talk about any activities you have done in mathematics classes that you have found interesting, or that you have really liked.
   What do you think is the effect of these activities?
   Similarly for uninteresting.

5. **Activities in classes other than mathematics that students find interesting – or uninteresting**
   What do you like doing most in your other classes (not mathematics) – either here or in previous classes?
   What do you think is the effect of these activities?
   Talk about any activities you have done in other classes that you have found interesting, or that you have really liked.
   Similarly for uninteresting.

6. **Ideas that students have for making mathematics classes interesting – especially new ideas.**
   Brainstorm ideas for this. In an ideal world, what things would you do in mathematics classes?
   Ask if any students have been in classes that have tried some of these. What were the effects that you noticed?

7. I will investigate the outside interests (individual interests) and also have a list of activities that researchers have found generally interest most people via the questionnaire – as well as any ideas that have come up in the focus group discussions.

Appendix 4: Focus group discussion points for teachers

1. **Priorities for teachers in the mathematics classroom.**
   What are the priorities you have when working in the mathematics classroom?
   Are these different than priorities in other subjects? How? Why?

2. **Things that teachers take into account when they are planning mathematics teaching.**
   What do you take into account when you are planning a unit of work?
   What do you take into account when you are planning particular lessons?
   Is this different than planning in other subjects? How? Why?

3. **Mathematics content that teachers think students find interesting – or uninteresting**
   Talk about any mathematics ideas that your students have found interesting.
   Talk about any times you have thought that your students found mathematics interesting.
   Similarly for uninteresting.
   How do these answers relate to your own interests?

4. **Activities in mathematics that teachers think students find interesting – or uninteresting**
   What activities do your students like doing most in your mathematics classes?
   Talk about any activities you have used in mathematics classes that your students have found interesting, or that they have really liked.
   What do you think is the effect of these activities?
   Similarly for uninteresting.
   How do these answers relate to your own interests?

5. **Activities in classes other than mathematics that teachers think students find interesting – or uninteresting**
   What do your students like doing most in your other classes (not mathematics)?
   What do you think is the effect of these activities?
   Talk about any activities you have used in other classes that your students have found interesting, or that they have really liked.
   Similarly for uninteresting.

6. **What use can be made of 'interest' in the mathematics classroom?**
   This may have already been answered above. I would like to find out what use teachers think can be made by using either students' individual interests or situational interests. I am interested in getting both practical classroom ideas and exploring 'what if' ones as well.

7. **Ideas that teachers have for making mathematics classes interesting.**
   Brainstorm ideas for this. In an ideal world, what things would you do to make mathematics interesting for students?
   Ask if any teachers have tried some of these in their classes. What were the effects that you noticed?

8. I will further investigate the ideas that come up in this discussion and also have a list of activities and content that researchers have found generally interest most people via the questionnaire.

Appendix 5: Student questionnaire

QUESTIONNAIRE

Thank you for taking part in the focus group discussions. The questions below relate to the ideas raised in these discussions.

Please remember that this questionnaire is aimed at finding out what makes, or would make, ***Mathematics lessons interesting*** to you.

If there are any questions that don't apply to you – just leave them blank.

Please answer the following. Tick the boxes that apply to you, and fill in any blanks you can.

Name ....

A. ***Activities***

1. I usually find **hands-on** activities in Mathematics

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

2. When I am allowed to **choose for myself** in the classroom I find learning Mathematics

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

3. When there is **variety** in what I do while learning Mathematics, I find it:

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

4. When I **work with others** I usually find learning Mathematics

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

I find learning Mathematics more interesting when I work:

By myself	*In Pairs*	*In Threes*	*Groups bigger than 3*
☐	☐	☐	☐

5. When my **teacher is enthusiastic** I find learning Mathematics

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

6. When Mathematics is **related to something else** that I know about, I find it

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

7. I find the **extra Mathematics tests and competitions** (like the New South Wales test, the Otago test, and Mathletics) make learning Mathematics

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

Which of these activities have you been involved in?

New South Wales	*Otago*	*Mathletics*
☐	☐	☐

8. I usually find learning mathematics that is **useful outside the classroom**

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

9. I usually find learning Mathematics that is **easy**

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

I usually find learning Mathematics that is **new**

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

I usually find learning Mathematics that is a **challenge**

Really interesting	*Interesting*	*Neutral*	*Boring*	*Really boring*
☐	☐	☐	☐	☐

B. *Content*

10. Some **mathematical ideas** are interesting in themselves. Please write down any mathematical ideas that you find interesting.

11. In the table below there is a list of **Mathematics topics** that some students have found interesting or boring. Please rate how interesting you usually find these topics.

    Leave blank any that you can't remember.

Topic	Really interesting	Interesting	Neutral	Boring	Really boring
Problem-solving					
Number (including decimals, fractions, percentages, and negative numbers)					
Computation and estimation					
Measurement (including length, area, volume, temperature, and estimating these)					
Measuring time					
Geometry (shape and space, angles, triangles and circles, 3-dimensional models)					
Symmetry and transformations (including translation, reflection, rotation, and enlargement)					
Algebra (exploring patterns and relationships using letters as numbers)					
Statistics (collecting displaying and interpreting data, using graphs)					
Probability					
All of Mathematics					

C. *Conditions*

12. Some students said that when they **feel good** they are more interested.

    Is this the same for you? What are some of the things that make you feel good or don't make you feel good when learning Mathematics?

13. Some students said that parts of their **classroom environment** made them more or less interested.

    Is this the same for you? What are some of the things about the classroom environment that make you more interested or less interested?

14. Some students said that when Mathematics was **fun** it was more interesting.

    Is this the same for you? What makes learning Mathematics **fun**?

General

15. Some teachers seem to make mathematics seem more interesting than others.

    What sorts of things can teachers do to make mathematics interesting?

16. How important to you is it that teachers try to make learning Mathematics more interesting?

Thank you for completing this questionnaire.

Appendix 6: Teacher questionnaire

QUESTIONNAIRE

Thank you for taking part in this research. The questions below relate to the ideas raised in the focus group discussions with students and teachers.

Please remember that this questionnaire is aimed at finding out what you think makes, or would make, ***Mathematics lessons interesting*** to the students.

If there are any questions that don't apply to you – just leave them blank.

Please answer the following. Tick the boxes that apply to you, and fill in any blanks you can.

Name ....

A. *Kinds of activities*

In this section please respond to three aspects of each kind of activity mentioned.

First Your perception of the **level of interest** students generally have in this kind of activity. Please choose from *very interesting, interesting, ho-hum,* and *boring* as your response.

Second **How often** you use this kind of activity with your Mathematics class. Please choose from *a lot, sometimes,* and *hardly ever* as your response.

Third State some **specific activities** of this kind you have used when teaching Mathematics.

1. **Hands-on activities.**

These are activities in which the student is an active participant. This includes using blocks or beans, all types of games, puzzles, role playing, making things, drawing, etc.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find hands-on activities	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
I use hands-on activities in my teaching	☐	☐	☐

Specific hands-on activities that I have used in class

2. **Student trust activities.**

These are activities in which students share ideas through dialogue, have choices, and use their own creativity. This includes welcoming and using student contributions, letting students make their own decisions about content, time to complete, and activities done.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find student trust activities	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
I use student trust activities in my teaching	☐	☐	☐

Specific student trust activities that I have used in class

3. **Variety of activities.**

Just what it says. This includes variety both within and across a series of lessons.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find a variety of activities	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
I use a variety of activities in my teaching	☐	☐	☐

Specific ways in which I have used variety in class

4. **Group activities**

These are activities carried out cooperatively in small groups (at least two). This includes doing group assessments, group demonstrations, and may include elements of student trust.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find group activities	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
I use group activities in my teaching	☐	☐	☐

Some specific ways I have used group activities in class are

5. **Teacher enthusiasm**

This could include humour, describing personal experiences, and being excited or enthusiastic. Activities like joining in as an equal member of a group, or dressing up, are examples of this.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find teacher enthusiasm	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
I use teacher enthusiasm	☐	☐	☐

Some specific ways I have used teacher enthusiasm in class are

6. **Relating content to students' individual interests or knowledge**

These are activities where the teacher builds the content to be taught around points of students' prior knowledge. This includes welcoming and using topical situations, or even situations that the teacher thinks might interest students.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find relating content to their prior knowledge	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
I relate my teaching to prior knowledge	☐	☐	☐

Some specific ways I have used students' prior knowledge in class are

7. **Variety of resources**

This is when resources such as field trips, outside mathematics competitions, and materials that are not frequently used (such as dice, or different texts) are used.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find using a variety of (novel) resources	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
The vary the resources in my teaching	☐	☐	☐

Some specific ways I have used a variety of resources in class are

8. **Practical activities**

These are activities that have some practical use outside the classroom. This includes making a model that may be used as a gift, or learning how compound interest increases investments.

	Very interesting	*Interesting*	*Ho-hum*	*Boring*
Students generally find practical activities	☐	☐	☐	☐

	A lot	*Sometimes*	*Hardly ever*
I use practical activities in my teaching	☐	☐	☐

Some specific ways I have used practical activities in class are

9. **Suitable tasks**

These are activities where the level of the content is appropriate for the students. Such tasks provide the right level of challenge so that students are not put off, but are also learning new ideas or consolidating previous ones.

Please comment on how you manage to find and use suitable tasks

B. ***Content***

10. Some **mathematical ideas and facts** are interesting in themselves. Please write down some mathematical ideas or facts that you think your students find interesting.

How are these interesting ideas able to be used in your mathematics classroom? Any ideas?

11. In the table below there is a list of **Mathematics topics** that some students have found interesting or boring. Please rate how interesting you usually find these topics, using one coloured pen, and in another colour, rate them in terms of perceived student interest.

Topic	Really interesting	Interesting	Neutral	Boring	Really boring
All of Mathematics					
Problem-solving					
Number (including decimals, fractions, percentages, and negative numbers)					
Computation and estimation					
Measurement (including length, area, volume,					

temperature, and estimating these)					
Measuring time					
Geometry (shape and space, angles, triangles and circles, 3-dimensional models)					
Symmetry and transformations (including translation, reflection, rotation, and enlargement)					
Algebra (exploring patterns and relationships using letters as numbers)					
Statistics (collecting displaying and interpreting data, using graphs)					
Probability					

C. *Conditions*

12. Some students said that when they **feel good** they are more interested.

    What, if anything, do you do to get your students to feel good, or stop them feeling bad, when learning Mathematics?

13. Some students said that parts of their **classroom environment** made them more or less interested.

    What, if anything, do you do that uses the classroom environment to create or sustain interest in your students within the Mathematics classroom?

14. Some students said that when Mathematics was **fun** it was more interesting.

    What makes things **fun**, and how can the idea of **fun** be used to create or sustain interest in your students while learning Mathematics?

D. *General*

15. How can you make learning Mathematics more interesting for your students?

16. How important is it to make learning Mathematics more interesting for your students? Why do you think this?

Thank you very much for completing this questionnaire.