CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature from several areas of research including mathematics education, streaming or ability-grouping, attitudes to mathematics and classroom learning environments. It also presents literature on the differences in males' and females' attitudes to mathematics and those from non-English speaking backgrounds. As the results unfolded, the review was supplemented. As Anderson (2004) said: "A literature review is a summary, analysis and interpretation of the theoretical, conceptual and research literature related to a theme or topic." (p. 76)

This chapter more specifically contains a literature review that covers areas such as types of mathematics classroom (2.2), an introduction to streaming (2.3), the effects of streaming on learning (2.4), the organisational implications of streaming (2.5), the sociological effects of streaming (2.6), intermediate positions on streaming (2.7), student attitudes to mathematics (2.8), classroom learning environments (2.9), differences by gender and language (2.10), and combining quantitative and qualitative research methods (2.11).

2.2 Types of Mathematics Classrooms

How a mathematics classroom operates is pivotal to student attitudes to mathematics and to their perception of their mathematics classroom. The nature of mathematics as a subject can create two diverse types of cultures. The first is a traditional 'teach and textbook' style which stifles the investigative side that is so vital to student learning.

The second type of mathematics classroom values investigation, problem solving and cooperative learning. Fagan (2005) sees the importance of classroom culture to learning:

> Quality classroom culture and discourse go a long way in fostering procedural fluency and conceptual understanding in mathematics. Opportunities to examine, extend, and generalise patterns enable students to learn algebra with

understanding and set mathematics in a real-world context. (p. 35)

Mathematics teachers know that there is always a better way to do what they are doing but acknowledge that it takes much time, effort and motivation to change a century old skill of imparting information and being the master of the classroom into being a facilitator of learning. One such teacher, Allen Gagnon (as cited in Schifter, 1996), a Head of Department in a high school, struggled with this change process, making the following comments:

> I have come to realise that my old view of teaching (presenting the material in a clear and concise manner) was too narrow in scope and did not take into account how learning takes place. As I struggle to gain insights into how my students learn, my teaching changes. . . There are many questions that must be answered. What is learning? How does learning occur? What is the role of the teacher in the learning process? What is the role of the student in the learning process? . . . What are my obligations to all my students, including the best and the so-called 'worst'? Where does the need to follow the curriculum fit into the puzzle? (pp. 1-2)

As Gagnon continues his reflections he asks more questions of himself when he sees the enormity of the process of changing a classroom style. The questions involve such concepts as whether continual group work and exploration of mathematics concepts is really necessary and whether his understanding of the concepts is really sufficient to facilitate this. The inevitable question of all teachers then emerges. Where will I find the time to do this properly and how can I stop these thoughts from daunting me to the point of desperation?

2.3 Introduction to Streaming

In 1977, Caroline Persell wrote a book that had a full chapter on the history of tracking (streaming) in America. A definition for tracking is that it is a practice which "places children together in a class on the basis of similar aptitude, achievement or aspirations." (Persell, 1977, p. 85). She goes on to explain that while the first recorded example of tracking was in St Louis in 1867 and was pursued vigorously by industrial capitalists, up until the date of writing it followed a

haphazard history of acceptance and rejection. In the 1920's and 1930's, when large numbers of blue collar workers were introduced into America, tracking was very popular in keeping a lower-stream to cater for the children of migrants. It then lost popularity until the 1950's when the 'space race' was on with Russia, and competition called for an academic elite. This time period also saw the movement of southern blacks to the northern cities along with the immigration of Puerto Ricans and Mexicans. This added more pressure to introduce the 'ethnic lower-stream'. It was reported that in the 1970's streaming was a widespread practice. Sometimes called *educational differentiation*, streaming was still economically, socially or racially driven.

There are many terms for the practice of streaming and many variations to the concept of streaming and it is called by different names in different countries. Table 2.1 is adapted from an English report called *Aspects of Secondary Education in England* in Harlen and Malcolm (1999) and illustrates the different names for ability grouping in all of its forms.

While it can be seen that there are specific terms in England for modifications of the same ideas, in Australia only three terms are used by practising teachers. *Streaming* is the practice of grouping students in the same year level by ability for one or more subjects. *Mixed-ability grouping* is keeping classes grouped randomly or by any other method apart from ability grouping. *Within-class grouping* is understood in the same way as England and America where teachers may construct smaller groups of students within their own classroom for teaching convenience. These groups may or may not be based on ability. In this study the Australian understanding is adopted, although international terms will be referred to.

Not only is ability grouping in all of its forms called different names across different cultures, but the very culture of a country dictates their attitudes and expectations towards ability grouping as a practice. As LeTendre , Hofer and Shimezu (2003) point out:

> Our analysis suggests that dominant cultural values determine what forms of tracking are perceived as legitimate and shape parent and adolescent

perceptions of choice and opportunity. . . . Basic beliefs about tracking may vary from nation to nation and cannot simply be translated from one language to another. (p. 44)

Table 2.1
Definitions of British and American Terms

English Term	Meaning	American equivalent
Streaming	Assigning students to classes based on some measure of ability.	*Tracking*
Setting	Regrouping of students for ability in specific subjects.	*Regrouping/Curriculum assignment*
Banding	A whole year group is divided into groups based on ability as with streaming. Bands may be unequal in size.	*No equivalent*
Mixed-ability grouping	Perceived ability is not considered when making class groups. An attempt is usually made to balance them for gender and cultural background.	*Heterogeneous grouping*
Within-class grouping	Groups are formed by the class teacher within the class to reduce the number of students receiving instruction at any one time. The groups may be homogeneous or heterogeneous.	*Within-class grouping.*

Adapted from "*Setting and Streaming: A Research Review*." By W. Harlen, and H. Malcolm, 1999, The Scottish Council for Research in Education.

The history of streaming contains many discrepancies in how the different tracks have been established over the years. Even where 'ability' as measured by standardised tests was used as a benchmark for placement into classes, the result was still a separation based on social class or ethnicity. (Rosenbaum, as cited in Persell, 1977). The research of this era uncovered and reported on many controversial practices in the name of streaming. These practices included: providing different

content to the different streams (Keddie, as cited in Young, 1971), using different instructional styles for the different streams (Sorenson, cited in Persell, 1977), higher streams receiving more empathy and praise while lower groups receive more direction and criticism (Rosenshine, as cited in Persell, 1977), better teachers placed into upper-streams (Hargraeves, 1967 as cited in Persell, 1977). Accompanying these inequalities were more careers guidance for upper-streams and less extra-curricular participation for lower-streams. (Persell, 1977).

According to George (1996) there exists so much evidence against streaming, yet the majority of schools are still practising it in some way or another. He records that in excess of 700 studies have been completed over the last half decade on streaming as a practice. The majority of these studies clearly indicate that it is not a desirable practice. It is a fact that around 85 percent of schools today still use ability grouping in some form.

It is said that there are three main reasons for streaming (DiMartino, 2005, p. 10):

1. It is easier and more efficient for the teacher
2. It helps students learn to their level and feel better about themselves
3. It limits the amount of failure slower students may experience and feel.

DiMartino (2005) disputes each of these points. He believes that when the evidence of research is taken together, streaming does not really help anybody. He points to studies that have shown that it is not possible to place students into groups based on ability and do it equitably or accurately. The history of research in this area also shows that students do not necessarily do better when put in classes of students with like ability. He also believes that the research shows a lower self-esteem for students in lower-streams. In fact he can see no positive aspects of streaming. The logical conclusion to what he is saying is that streaming is polarising, creates elitism, sets low expectations for both lower set students and teachers, wastes time, and encourages segregation.

While the previous statements are compelling, when the research is studied carefully, they do not constitute universal conclusions. For the statements to be true one would

have to make the assumption that treating different people equally is in fact equitable. As Thomas Jefferson is reported by Fielder, Lange and Winebrenner (2002) to have said: "Nothing is so unequal as the equal treatment of unequal people."

For the first half of the 20th century it was a given fact that mathematics classes would be streamed and there seemed no cause to question this practice. (Wiliam & Bartholomew, 2004). Indeed this happened for more than mathematics classes as students were often streamed into ability groups and left there for all subjects, invariably for the duration of their schooling. When the 1960's arrived and there was an interest aroused in the individual learner, the practice of streaming began to be questioned (Jackson, 1964) and the streaming between classes for both primary schools and secondary schools declined in the 1960-1980 time period. During this period research was conducted that highlighted dissatisfaction from lower-stream students (eg. Hargraeves, 1967). Other research showed that streaming really did not bring about significant gains in academic achievement. (eg. Newbold, 1977). This trend of moving away from streaming has not continued into the latter part of the last century. Despite the evidence presented in the research, streaming is still a widely held practice in most secondary schools, particularly in the area of mathematics. Wiliam and Bartholomew (2004) report that in England around 90 percent of schools still stream for mathematics and the British government has even advocated the use of streaming in all secondary schools despite being reported as saying that they are interested in developing educational practice that is informed by research evidence.

Van Houtte (2004) provides an historical summary of streaming research from a teacher's point of view from 1967 onwards:

(a) There is a history of lower-streams receiving less interesting and less challenging classes. (Hargraeves, 1967; Metz, 1978)
(b) Less is expected from lower-stream students than from higher stream students in the academic area. (Hargraeves, 1967; Metz, 1978)
(c) A higher work rate and an ability to solve problems is expected of upper-stream students. (Hargraeves, 1967; Metz, 1978)

(d) Memorisation and a constant stream of exercises is what lower-stream students came to expect over the years.' (Goodlad, 1984; Persell, 1977)
(e) In upper-streams the academic gets the focus whereas in lower-streams behaviour is the focus. (Schwartz ,1981; Murphy & Halllinger, 1989)
(f) The whole atmosphere of a higher stream as set by the teacher is generally more set for achievement than in the lower-stream. (Oakes, 1985)
(g) Lower-stream students are expected to just do their work without the benefit of higher order explanations and very little direction as to goal or expectations. (Schwartz, 1981)
(h) Because teachers in higher streams are more motivated, they generally put more effort into their lesson preparation. (Rosenbaum, as cited in Persell, 1977; Goodlad, 1984; Oakes, 1985)
(i) Teachers can tend to take on the position of their students and thus end up streaming themselves. (Finley, 1984)

There has been a significant move towards eliminating streamed classes in America with research concluding that streaming widens the gap between those who are perceived to be upper-stream and those who are perceived to be lower-stream. For example, Lockwood and Cleveland (2002, p. 3) make several statements about the effects of streaming. They believe that it is an ongoing challenge for teachers, parents and all concerned with education to get that balance between equity and excellence. Their conclusion is that removing streaming from schools is the best way to achieve both of these objectives, given that there is no data to support the theory that ability grouping adds to overall achievement. It is accepted that streaming does create inequality.

These are all generalisations but they do describe a culture that can exist in schools that practise streaming. Either the teachers who are placed with lower-stream students are not as skilled as those for upper-stream, or teachers become discouraged by an institutionalised lower-stream class, expecting poor behaviour and thereby losing their motivation to help them.

At this current point in time the British government is supporting the selection of students based on ability. It is interesting that parent groups are against selection by

ability. Shaw (2004) wrote in the Times Educational Supplement: "While the British government plans to expand support for schools that choose students based on ability, a recent survey reveals that parents are overwhelmingly opposed to selection by ability." (p. 1)

2.4 The Effects of Streaming on Learning

This section will present a number of references that discuss the position of streaming as it appears in the existing literature. This study seeks to clarify some of these issues and for a specific sample, identify the relative merits or otherwise of streaming in mathematics education in terms of their learning environments.

Depending on the country of origin for each of the studies referred to in this section, what is called 'streaming' in Australia is referred to as 'tracking' in America and as 'setting' in Europe. According to Alexander and Cook (1982), tracking is "setting up distinctive, internally coherent programs of study congruent with students' scholastic interests and competencies and tailored to their anticipated educational and vocational needs." (p. 626)

Marsh and Raywid (1994) gave eight good reasons why streaming should not continue to be practised in schools:

1. The best teachers are often assigned to the top streams
2. Differences in content
3. Differences in quality of instruction
4. Too little is demanded of lower-stream classes
5. Students encounter an atmosphere of less motivation amongst lower-stream students.
6. Minority students often end up grouped together
7. Career opportunities could suffer
8. Students may be put in the wrong stream by mistake.

Eliminating streaming adds to the confusion and conflicting evidence available on the winners and losers if a school were to take this path. Brewer, Rees, and Argys (1995) have conducted research which shows that reverting to mixed-ability would

itself “create winners and losers. . . . Our estimates imply that detracking all students currently enrolled in homogeneous classes would produce a net 1.7% drop in the average mathematics score.” (p. 214) This is an interesting assertion to make and one that would be very difficult to measure with any significance or report with confidence. Indeed Jaeger and Hattie (1995) say that further research shows that the difference in scores is so negligible that it can go either way and probably should not be quoted. They also make the comment that sometimes students stream themselves by choosing a certain subject over another, more academic one.

Brewer, Rees and Argys (1996) answer their critics by again stating that there will be winners and losers if tracking is abolished. The better students will have their scores brought down while the poorer students will show improvements in scores. They say that the 1.7 percent decline in student test results, referred to as insignificant by critics, represents a net result. The actual decrease in upper-stream students' mathematics results came out to 8.1 percent. The increase for lower-stream students put in a mixed-ability class would average out at 8.7 percent. (Brewer, Rees and Argys, 1996) Their question is to ask who should make the call as to which result is more desirable. It is a difficult sociological question to answer. Which group should be performing below their best due to the way the school is organized? Certainly the parents of the upper-stream students would traditionally have the stronger voice in the school community.

Hoffer (1992) had the same to say some years ago when his research showed that any gains from ability grouping are too small to be significant. Indeed placing students from a mixed-ability class into an upper-stream produces a weak positive net result while placing a student from a mixed-ability class into a lower-stream class produces a strong negative result. This is just one more paper to illustrate how streaming benefits the upper group in a minor way but disadvantages the lower group in a more pronounced way.

A study by Venkatakrishnan and Wiliam (2003) reports similar findings. While it was stated that streaming has different effects on different students, in general it was found that upper-stream students did not receive a large advantage by being streamed, mixed-ability students kept performing at their previous level and lower

performing students were disadvantaged. Like other studies reported in this chapter, the difference in academic attainment after streaming was introduced, was very small.

In a review of studies on ability grouping and academic performance compiled by Slavin (1990), 29 different studies were identified and the net effects of ability grouping were found to be very close to zero. The only exception to this seemed to be in the humanities area where the heterogeneous classes tended to perform better. These results are in contrast to other research presented in this chapter which indicates a slight improvement for upper-streams and a significant decrease in achievement for lower-streams under ability grouping.

Another perception is given by Boaler, Wiliam and Brown (2000) who use research to blame poor International Mathematics Study results in the United Kingdom, directly on streaming in that country. It is suggested that there are only two factors that affect student achievement in mathematics – "opportunity to learn and the degree of curricular homogeneity." (p. 641). They go on to say that streamed classes and curricular homogeneity are mutually exclusive. The intent of their study has similarities to the current proposal for this thesis. They study student attitudes and achievement in mathematics in ability-grouped schools. Their conclusions are that ability grouping causes negative feeling towards the subject.

Boaler, Wiliam and Brown, (2000) also comment on much of the research provided in the area of streaming for ability as very clearly indicating a slight increase in academic achievement for higher stream students, but significant decreases in performance for lower-stream students. The comment is made that most of this research has been quantitative with little or no classroom observations or any other mechanisms whereby other aspects could be measured, such as: "The way that tracking and setting impact upon students' learning of mathematics, the processes by which it takes effect, or the differential impact it has upon students." (p. 631)

It stands to reason that when streaming occurs across the board and when students are condemned to a particular set indefinitely, that some negative aspects of streaming brought out in the research may have an impact on students. There seems

to be evidence in the research for the existence of poorer teaching methodologies in lower-stream classes with less qualified teachers. One might also consider the impact on individual students if they are continually labelled as and mixing with students considered as inferior because of socio-economic status, ethic background or perceived lower ability.

Van Houtte (2004) comments on the academic culture in school staffs as it relates to streaming. The results are quite telling from a sociological viewpoint. One conclusion is of particular concern. He reports: "It has been shown that teachers in lower tracks are less academically oriented than those in higher tracks, because they have a lower opinion of their pupils." (p. 354)

He goes on to quote Hallinan (1994) in saying what has been highlighted from the literature already – that there is really no advantage in streaming. Mediocre pupils will not be advantaged, good students will benefit from streaming but poor pupils will suffer the opposite effect.

Van Houtte (2004) draws the conclusion that teachers also become tracked according to the classes they teach. They subconsciously acquire the same status as their students. DeLany (1998) says: "The appreciation teachers receive from the outside world depends on the ability level of their students." (p. 358). It stands to reason therefore that teachers not only prefer to teach the higher stream, but usually put a lot more effort into it.

This theory is taken further by Van Houtte (2006) where he says that in the lower-streams teaching methods emphasise facts and basic skills whereas in the upper-streams teachers expect more of their students and present their material in a more enthusiastic manner. In a study conducted in Belgium by Van Houtte, he found that teachers trust students in 'general' schools more than they do those in 'vocational' schools. The level of trust a teacher has for the students is associated with the level of satisfaction the teacher has with their work, which in turn leads to the amount of effort they put into their teaching. In Belgium not only are the classes streamed but the schools are also streamed. The vocational schools represent what could be known as the lower-stream.

Arbor (2004, p. 15) highlighted several reasons why streaming does not work:

(a) It is not realistic to think that a streamed class is strictly homogeneous. However classes are divided, teachers will still have a huge range of abilities to deal with.
(b) Low income, ethnic minority and disadvantaged students usually find themselves in lower-streams.
(c) Even where schools say that their streaming policy encourages mobility between the streams, the tendency is for the placements to become fixed. Where mobility does occur it is much more likely to be a downward movement than an upward movement.
(d) When a student reaches the stage in school where streaming begins to occur, it is most likely that the student has been permanently labelled in terms of achievement and future career.
(e) Students with behaviour problems usually end up in the same class which makes the behaviour management of that class difficult from the start.
(f) 'Teachers get the message, implicitly and overtly, not to have high expectations for low-track students.' (p. 15)

It should be no surprise that Carbonaro (2005) established a link between the effort of students, tracking and their achievement. This study found that students in upper-streams tend to put a lot more effort into their work than students in the lower-streams. The factors affecting lower-streams and causing this difference in effort are firstly that historically the student has not tried and has not achieved. The experiences of the students in lower-streams also reinforce the non-urgent approach to learning.

Carbonaro (2005) goes on to quote a variety of researchers who have previously established the link between ability grouping and academic outcomes: "Research has strongly suggested that students in higher tracks and ability groups tend to learn more than comparable students in lower tracks and ability groups." (p. 27)

The line of logic is such that the classroom learning environment of an upper-stream class is more conducive to student effort. Effort is measured by how much homework is completed, how attentive the student is in class and how prepared they

are for tests and exams. It then follows that this type of effort leads to greater learning

Carbonaro (2005) points out four main reasons why placement in a certain track may form a positive correlation with student learning. Firstly, "The sub-culture of a lower-stream class which often promotes antischool norms actually serves to disengage students from the learning process." (p. 29) Secondly the concept of 'prior effort' could not only be the means by which a student is selected to a higher stream, it is certainly a precursor to better results because of the previously stored knowledge. The converse is also true. Thirdly the higher stream students will almost certainly have better self-belief and ambition to achieve. Finally, where a student is placed determines the 'cognitive demands' placed upon them.

In what is a complex and extensive study, Carbonaro (2005, p. 39) comes up with four main conclusions that link effort, stream and learning:

1. The higher a student's track, the more effort she or he exerts.
2. Most of the differences in effort across tracks are explained by differences in prior effort and achievement across tracks, but factors relating to students' experiences within tracks also explain track differences in effort.
3. Effort is an important predictor of achievement
4. The effect of effort on achievement gains does not vary across tracks.

Arbor (2004) has reported on case studies with schools in America which have eliminated streaming. Contrary to what other research has shown, schools used by Arbor show significant increases in test scores after creating mixed-ability classes.

> Getting rid of tracking and having students of varying ability levels in the same class can be a challenging process but is worth the effort, say officials of South Side High School . . . and Noble High School . . where detracking led to improved academic performance for students at all achievement levels and to better school climates. (p. 15)

Arbor (2004) found that in one of the schools the passing rate on the state-wide examination went from 72 percent to 95 percent over seven years. It is also significant that: "Gains were also dramatic in percentages of African American, Latino and low-socioeconomic status students taking and passing advanced maths courses." (p. 16)

It must be pointed out that the detracking was done with quite a few conditions. These conditions would be vital to success. Firstly it would be necessary to raise the numbers in the top level by making advanced level courses available to the majority and provide the lower achievers with lots of support. Secondly provision must be made initially for in-class training for teachers doing mixed-ability. Finally the parents must be kept well informed and assured that the school will revert back to the old plan if it does not work.

Boaler, Wiliam and Brown (2000) report on research that was longitudinal over four years and was carried out in six English schools. It was not designed to study ability grouping but to a certain extent that is part of what emerged. The way students perceived their mathematics classroom learning environment was very evident. Following are three of the interim observations. The first observation was that approximately one third of the students taught in the highest ability groups were disadvantaged by their placement in these groups because of high expectations, fast-paced lessons and pressure to succeed. Secondly, students from a range of groups were severely disaffected by the limits placed upon their attainment. Students reported that they gave up on mathematics when they discovered their teachers had been preparing them for examinations that gave access to only the lowest grades. Finally social class had influenced setting decisions, resulting in disproportionate numbers of working class students being allocated to low sets. (Boaler, Wiliam and Brown, 2000) Indeed, the preliminary results of this study were that out of 48 students, 40 wanted either to change the group they were in or to go back to mixed-ability classes. The students reported that the net result of streaming for them was that the way teaching was carried out under a streaming regime adversely affected "both their attitude to mathematics and their ability to learn mathematics." (p. 636)

Rousseau and Tate (2003) reflect upon what may constitute equity in school mathematics classes. They report conversations with teachers who were asked what equity means in the teaching of mathematics. It was discovered that teachers mostly have a restricted view of what equality is. They believed that equality in mathematics teaching meant that they treated all students the same. Rousseau and Tate argue that the teacher looking for equity in their profession should be aiming at equity of outcome rather than equity of process.

A comprehensive study by Wiliam and Bartholomew (2004) followed the academic results of students from seven schools in England over two stages as they worked towards the GCSE examinations. Not only did they find no significant value added to academic results from streaming the classes, but they discovered other effects of the streaming process as they worked on their research. They saw that ability grouping, either within classes or between classes, was done on assumptions about ability, achievement or even motivation. The schools were not able to give a clear idea of how the split was done or what criteria were used. This research took in survey data, interview data and observational data.

Boaler, Wiliam and Brown (2000) had previously observed that teachers tended to change their style of teaching when working with streamed classes as opposed to mixed-ability classes. Wiliam and Bartholomew (2004) observed the same thing, noticing that teachers would often overestimate the capability of students in the upper-stream, giving them work that was sometimes beyond them. At the same time the same teacher would often underestimate the ability and capabilities of the lower-stream students. They also found that in one school, though the school may have reported that the separation into streams was done on the basis of 'attainment', the lower class was often referred to as the 'behaviour class'. Even when the majority of the 'behaviour' students had been excluded from the school, the class kept the same label.

Wiliam and Bartholomew (2004) conclude: "It appears that the most pernicious effects of setting may not be necessary consequences of grouping students by ability, but appear when teachers use traditional, teacher-directed whole-class teaching." (p. 289) Research can therefore be said to have shown that the teacher effect on

classroom learning environment is of paramount importance and can be responsible for changing grades, perceived environments and even attitudes.

By reviewing the literature it becomes evident that concerns that were present, researched and reported on in the 1970's and the 1990's with regard to streaming, are the same issues that are reported on in the 21st century. A comparison of comments from 1977, 1996 and 2000 can be seen in Table 2.2. A similarity can be noticed in that in all cases a slight increase in academic results for the upper-stream is reported after streaming while for the lower-stream there appears to be a slight decrease.

Table 2.2
Comparison of Comments on Academic Streaming from 1977 to 2000

1977	1990	2000
"There is a slight trend towards improving the achievement of high-ability groups, but this is offset by the substantial losses of the 'average' and 'low' groups." Persell (1977, p. 39)	"Researchers who have compared gains made by students in different tracks have generally concluded that controlling for ability level, socio-economic status, and other control variables, being in the top track accelerates achievement and being in the low track significantly reduces achievement." Slavin (1996, p. 132)	"A slight increase in academic achievement for higher stream students, but significant decreases in performance for lower' stream students." Boaler, Wiliam and Brown, (2000, p. 644)

Despite the quantity of literature presented in this section that opposes ability grouping on the basis that there is little positive effect for the upper-streams while there is a cost to pay with the lower-streams, there is a nucleus of researchers who believe that these studies are flawed for different reasons. Bode (as cited in Tiesco, 2003) believes that the disagreements in the area of ability grouping have been over equity or excellence. She believes that the studies that have commented on the equity issue have been "largely qualitative and anecdotal in nature". (p. 34)

Tiesco (2003) goes on to report that Slavin's studies have left out the gifted classes and the special needs classes when doing his analysis because they have curricular adjustments. This is ignoring the possibly large improvements to gifted student

scores after streaming. Another problem with previous research on ability grouping that Tiesco points out is that most studies have chosen schools that use some form of standardised test to separate the classes into ability groups whereas most schools today use demonstrated performance as a means of separating students into ability groups. This is one of the problems in referring to studies that are quite old. Tiesco (2004) believes that it only with curricular adjustment that the real benefits of ability grouping for teachers and students begin to emerge.

2.5 The Organisational Implications of Streaming

Linchevski and Kutscher (1998) cite several pieces of research which indicate that given an innovative setting it is possible to succeed with a mixed-ability group. Teachers can teach mixed-ability classes successfully and be satisfied with what they are doing provided they are supported in all ways – with resources, in-service courses and discipline. (p. 535)

Mallery and Mallery (1999) refer to research that points out that perhaps streaming would work if lower-streams were given the same amount of funding and some very good teachers. Of course it will not work if lower-streams are given second rate teachers and are rejected financially.

Gamoran and Weinstein (1995) go along with the idea of improving lower-stream classes rather than radically eliminating streaming in schools. They said that moving towards a mixed-ability class in mathematics does not guarantee equality of achievement or of opportunity. Just because students may be exposed to the same content in mixed-ability classes does not mean there will be equal performance. According to Gamoran and Weinstein, if students are divided by ability and then given excellent lessons from motivated and well organised teachers, there is no reason why they should not succeed. The curriculum would have to be organised so that the lower-stream has a natural progression to worthwhile career options.

Wiliam and Bartholomew (2004) in a study of streaming using seven schools in England (referred to in section 2.4) discovered that from an organisational point of view, how streamed classes are staffed is very important in terms of how it effects classroom learning environments. They found that teachers in lower-stream

mathematics classes were usually the least qualified in teaching mathematics, they expected little of their students, the work given was not up to standard, they ignored students' requests for more challenging work and they had a very narrow range of teaching techniques. On the other hand the upper-streams were found to have the most qualified teachers whose expectations were often too high, leaving students behind. It seemed that teachers of streamed classes saw their students as being of common ability whereas the same teachers, when working with mixed-ability classes tended to teach differently. They used a wider range of teaching methods and catered better for individual differences.

Ireson, Hallam and Hurley (2005) conducted a study of some 6000 Year 9 students and followed their progress through to GCSE examinations. They found that results were no better for those of similar ability whether they were in higher streams or not. The implication for organisation is that setting up what a school thinks is homogeneous groupings of students is found to become not homogeneous over the years as abilities and motivations of the students change and yet mobility between classes becomes restricted. The end result is classes that exhibit a wide range of attainments. It could be said that the purpose of streaming in the first place is defeated.

2.6 The Sociological Roots and Effects of Streaming

Part of the classroom learning environment data collection to be undertaken in this study includes sociological aspects of a student's perceptions of their learning environments. For example, the students will be surveyed to find out about how the members of their class cooperate with each other or how cohesive they are or whether the students consider they are being treated equally in the classroom. Indeed, many of the arguments one will read against streaming as a practice are arguments of social justice. This section contains sources that refer to the social aspects of streaming.

Apart from the obvious arguments against streaming based on the fact that there is no apparent academic advantage to the students by doing so, the overwhelming discussion over the last four decades has revolved around the sociological implications of streaming. In fact Slavin (1996) quotes many researchers of that era

who believe that tracking is a principal source of social inequality and that it causes or greatly magnifies differences along lines of class and ethnicity (eg., Braddock, as cited in Slavin 1996; Jones, as cited in Slavin, 1996; Schafer & Olexa, as cited in Slavin, 1996; Vanfossen, Jones & Spade, as cited in Slavin, 1996).

Gillborn (2001), works in the field of educational policy research in England and has a specific interest in educational inequality. He wrote:

> It is always possible to find a plausible reason why a Black child should be excluded; why an individual should be placed in a lower ranked teaching group; or why a bilingual pupil cannot receive the attention they are due because of the pragmatic necessity in a situation where there are simply insufficient resources for all. (p. 105)

In his study, Gillborn (2001) found that in mathematics education in England, as students are prepared for the GCSE, they are placed into one of three tiers where only the top tier can achieve an 'A' grade and where the highest a bottom tier student can achieve is a 'D' grade. The Black pupils and the lower socio-economic White students were found by Gillborn to be over-represented in the bottom tier. He comments that neither side of the 'educational equality' debate in England has a grasp of the issues that marginalise students in schools. Selection according to behaviour or perceived ability will continue to be practised despite the disadvantage caused to children of working class or minority ethnic backgrounds.

In a later paper, Gillborn (2005) confirms the fact that while separation by 'setting' within schools continues to be supported by the British government, there are an increasing number of separate schools being established on the basis of 'aptitude' or 'ability'. (Edwards and Tomlinson as cited in Gillborn, 2005) As expected, Blacks and minority groups are under-represented in these schools. In fact, White teachers have consistently been found in studies to place a disproportionate number of Black students in lower-streams when asked to judge their potential, their attitude or their motivation. (Sukhnandan & Lee, cited in Gillborn, 2005). As Gillborn (2005) points out, a combination of these circumstances has the following results:

> These decisions frequently have a cumulative effect whereby the initial decision compounds inequity upon inequity until success can become literally impossible. For example where students are placed in low ranked teaching groups they frequently cover a restricted curriculum; their teachers have systematically lower expectations of them; and in many high-stakes tests in England they are entered for low 'tiered' examinations where only a limited number of grades are available. (p. 496)

Given that there appears to be an over-representation of ethnic or coloured students in lower-streams and also given that there is a question surrounding the accuracy and finality of any test instrument that may be used to allocate students into streams without compensating for second language difficulties or other social limitations, the physical splitting of students into streams has to be questioned on a sociological basis. This may not be an issue for the very advanced mathematics students or for those who are obviously struggling with the very basics, but for the vast majority of those students who are considered or measured to be 'average', the stream they end up in may have a sociological basis and will almost certainly have a sociological implication.

Oakes (1992) reports on the over-representation of students from low income, African-American and Latino families in lower-stream groups. She reinforces the fact that:

> New research investigating track-related student outcomes and reanalysis of earlier studies, supports the increasingly clear and consistent (if not yet universally accepted) conclusion that this common way of organising students for instruction is, in most instances, neither equitable nor effective. (p. 12)

It is clearly not politically or socially correct in today's climate to divide classes on the basis of race, religion or class, and therefore the sociological question that must be asked is what makes it correct to divide a class for ability. Skovsmose & Valero (as cited in Atweh, Forgasz & Nebres, 2001) said:

> It is broadly assumed that it is not possible to justify difference in 'treatment' with reference to race, gender, religion, class, or any other similar category. Where did the idea that 'ability' might be an exception emerge from? . . . We believe that if an educational system does set up examinations with the possibility of failure, and if public stratification takes the form of streaming, then the links between mathematics education and democracy are broken. (p. 51)

There is much in the literature about the sociological effects of streaming. Marsh and Raywid (1994) say: "For all but the youngsters in the highest track, the practice of tracking renders schools less interesting, less productive and less rewarding." (p. 318)

Research along these lines was carried out by Oakes and Wells (1998) who studied schools that had decided to eliminate streaming, but only to the extent that would enable all students to get access to similar curriculum levels without any one group being exposed to classrooms that were inferior in resources, teacher, expectations, curriculum or environment. From their investigations in ten different schools that tried many diverse methods to bring the learning levels of lower-streams up to an equitable level, they discovered there was very limited success. The reason for this they found to be the many obstacles that society presented for them. These challenges were sometimes cultural and sometimes political. They found deeply ingrained belief structures surrounding the ideas "about intelligence, racial differences, social stratification, and privilege." (p. 40)

One very interesting result from a study conducted by Kemp and Watkins (1996) on the effects of academic streaming on self-esteem in students from Hong Kong concluded quite the opposite to other studies. Their conclusion was that high-ability children tend to have their self-esteem damaged when put into upper-streams while lower ability children tend to have their self-esteem boosted by being in lower ability streams. Their explanation for this phenomena was that:

> In a high-ability class, pupils may compare themselves primarily with other members of that class and thus view their own academic competence less

highly than they would if they were in a class with students of varying ability levels. The opposite effect can occur for a low-ability child in a class with other low-ability children. Although the impact is likely to be strongest for academic self-esteem, there may be residual effects on other components of the self as well as on general self-esteem. (p. 652)

In the text of a debate reported by Wilson and Davis (2005), there is direct evidence of the many diverse opinions that proliferate on streaming. The problem is that most of the arguments on both sides can be supported with logic or research. Following are some of the case studies:

(a) A gifted ex-high school student who is against streaming because it took him away from other students he wanted to get to know. (Wilson & Davis, 2005)
(b) A teacher of 14 years who believes in differentiating the curriculum for her mixed-ability class. She believes that: "Students, when they are together in a mixed-ability group, will develop more tolerance of one another and possibly a new attitude towards learning." (Wilson & Davis, 2005, p. 46)
(c) A teacher at a highly academic school who supports the right of students to work to their ability level. She supports tracking but not across the board. They may be in one set for mathematics and another one for English. "No one is locked into a level and students are constantly evaluated and moved into levels that will meet their need to excel." (Wilson & Davis, 2005, p. 46)
(d) "In non-ability grouped classes, the same students always seem to be answering the questions and getting the A's. In ability grouped classes, students have more opportunities to answer questions in discussion sessions, and questions that others won't think are weak, and find validation as class leaders." (Wilson & Davis, 2005, p. 47).

Fielder, Lange and Winebrenner (2002) are particularly concerned about the fate of the gifted in an environment that eliminates streaming in the form of gifted programs. They reported that: 'The antitracking movement of the 1990s led to the anti-ability grouping movement that locked some gifted students out of the challenging programs they needed.' (p. 108) Fielder et al. ask the question whether, in the name of equality we can allow the underachievement of the gifted: "Can it be

that our school systems are actually giving tacit approval to create underachievement in one ability group so that the needs of the other ability groups can be served? This, indeed is egalitarianism at its worst." (p. 109)

Fielder et al. (2002) go on to say that it could be more elitist to put a couple of gifted children in a main stream where their intelligence is so obvious to the whole class. This could, in itself tend to create snobbery: "Unless gifted students are placed in situations where they can be challenged by intellectual peers, the possibilities that they will develop an elitist attitude might well be expected to increase." (p. 110)

Historically the British system of education, which has tended to permeate many education systems in the world, was to group students by perceived ability on the basis that "students have relatively fixed levels of ability and need to be taught accordingly." (Boaler, Wiliam & Brown, 2000, p. 632)

In the same piece of research, Boaler et al. (2000) report that in the 1960's all but 4 percent of schools streamed their classes for ability. The same study "revealed the overrepresentation of working class students in low streams and the tendency of schools to allocate teachers with less experience and fewer qualifications to such groups." (p. 634)

They go on to say that the 1970's and 1980's saw: "A growing support for mixed-ability teaching." (p. 634) It seems that there was a short-lived general push for 'educational equality' which, by the 1990's was starting to be challenged by another push for academic success, particularly for the academically gifted. In fact today, in England many schools that had opted for mixed-ability classes in the 1980's, have returned to ability grouping.

Ascher (1992) reports a strong feeling about the social disadvantages of streaming:

> Although tracking remains controversial among both educators and parents, there has been a recent policy consensus that the negative effects of tracking on lower track students are so severe that schools should move towards detracking. Successful detracking rests on an 'inclusive' school culture. It

> also depends on a curriculum that is interactive and problem-solving, as well as on assessment processes that support such a curriculum. Schools embarked on detracking must draw in parents, students, and teachers, not only to ensure that these groups buy into the change, but to teach them new egalitarian ways of thinking, and to use them to help reconsider existing school routines. (p. 5)

Why would schools, or education systems continue with streaming when its negative effects are clearly demonstrated in research (Gamoran, 1992; Boaler, Wiliam & Brown, 2000)? Zevenbergen (2005) asks this question and then goes on to say that in some cases (eg. UK) streaming is mandated. It is interesting that while the British government claims to want to make policy based on research evidence, they are still promoting streaming or setting as the preferred protocol. Gillborn (2005) condemns streaming as a method of separating students and even calls the practice 'racist'. His research and writing is prolific and directed, yet the British government choose not to be informed by his research.

Zevenbergen (2005) goes on to say that the practice of streaming can be self-perpetuating:

> The practice of ability grouping helps to reproduce the status quo, and can be detrimental to the goals of social justice. I propose that when the practice is enacted in mathematics classrooms it can create a learning environment that becomes internalised as a mathematical *habitus.* Where experiences are positive, there is greater potential for students to identify with the subject. (p. 608)

On the other side Zevenbergen (2005) suggests that a negative experience with mathematics classes could lead to a *habitus* that prevents the students from wanting to continue with mathematics as a subject.

Slavin (1995) agrees that because most research has indicated a zero net gain in scores for students in streamed classes, there is therefore no reason to stream given the social inequities that streaming infers.

Also from a sociological point of view, Ansalone (2002) is opposed to streaming. He says:

> As an educational delivery system, tracking does not promote cognitive achievement, helps to stimulate a negative self-concept in some students, and fosters resentment and misconduct. In so doing, it may be an important contributing factor in the problem of attrition. (p. 83)

He sees as an additional disadvantage the fact that teachers may create imagined positive or negative self-concept among students according to which stream they are in. He believes that "assignment to a lower track may contribute to a feeling of resentment and hostility, which can eventually lead to student withdrawal." (p. 85)

It is also a social reality that friendships formed at school and in classes have a large impact on a student's school performance and success after completion of school. Heck, Price and Thomas (2004), when commenting on courses students take, say that: "The teaching that goes on within them, and the peer friendships formed are factors that affect students' educational experiences and post-high school aspirations." (p. 321)

What impact does society have on student perspectives? Metz (1990) believes that a student's perspective on life will be shaped by the community and its subgroups, the school community itself and the teaching staff of the school.

Van Houtte (2004) compares the social impact on groups of students as well as on individual students. He says that achievement of students at school is affected by how they are treated as individuals within a classroom, as well as how they are treated within a group that they identify with, such as a particular stream within a subject.

Herb (1997) points out that tracking and ability-grouping are quite different. Tracking puts the student into a category permanently whereas ability-grouping can be done within classes and tends to be more flexible. Unfortunately it is very difficult to prevent one from leading on to the other. "Society still carries the

baggage of classism and racism and that baggage will flow into the school system." (p. 12)

Given that the student sample for this study is taken from Seventh-day Adventist schools it is interesting to note that the 'Christian' philosophy adds another aspect to the sociological debate on streaming. Simpson (1985) said: "To condemn all forms of ability grouping and tracking would be naïve. Yet to abuse the practice is immoral. Finding the middle ground for Seventh-day Adventist education is not unlike walking through the minefield of public school curriculum decisions." (p. 41) The abuse of tracking she is referring to is a reflection of the fact that when students are placed in a track purely on the basis of test results, it may not be ability causing those results but rather discipline, maturation, support or motivation.

The issue of streaming has even been discussed at the Southern Christian Leadership Conference where part of their campaign was to help parents and communities recognise when children were being tracked and also to promulgate the philosophy "that says all children can learn at high levels." (Herb, 1997, p. 12)

In the same paper Rose Sanders of the Coalition of Alabamians Reforming Education in Selma, stated: "How you implement this philosophy is through a unified required core curriculum that is enriched in mathematics and science. Unified is important because it means students can't be taught separately but together." (p. 12)

Again in the same paper Emma Owens of Clemson University is quoted as saying that teachers must be trained in differentiated curriculum specialising in mathematics and science and become comfortable with students of differing ability. She says: "The workplace is tough enough for teachers, who are being asked to teach kids of all levels at the same time. It takes a special teacher to teach both groups." (p. 12)
A common question that arises from proponents of streaming is the comparison to the sporting arena. From a sociological perspective, why is it that the community is quite ready to accept the achievements and thus the separation of the 'sporting elite', but not so ready to accept the 'academic elite'? Even the naming of a sports team

such as the 'First Eleven' in cricket could be seen as pure elitism but is accepted by society.

Tammi (as cited in Fiedler et al, 2002) answered this question by saying that academic success is a general expectation for all members of society whereas sporting success may not be the desire or the need of all:

> Not all students have the ability or desire to participate on a varsity sports team, yet I have never heard any school official argue that singling out talented athletes for team membership to the exclusion of others is elitist. In fact, school districts and local community agencies go to great lengths applauding these athletes' efforts and supporting them in development. (p. 44)

According to Arbor (2004), eliminating streaming led to an improved school climate, greatly improved test results and better race relations within the school.

Ansalone and Biafora (2004) point out that when a school uses streaming and has done for many years, it forms part of the culture of the school and where there becomes a desire to revert to mixed-ability classes it needs to be done to a plan. This plan should involve a slower evolving process given that streaming is so embedded in the culture of the school. A timeline should be produced that has target dates for different levels of achievement in the undoing of streaming within the school.

2.7 Intermediate Positions on Streaming

As mentioned earlier, there are many positions that are not extreme in either direction. Following are some examples.

Ireson and Hallam (1999) comment on the large amount of research and the widely differing results that largely fail to come to any conclusion – or rather tend to come to many different conclusions. They do give some alternatives to streaming. Streaming could be maintained but actively work to reduce its negative effects. Another possibility would be to place less emphasis on ability and more on effort.

Methods could also be improved for teaching mixed-ability classes.

In a study conducted by Ireson, Hallam and Plewis (2001) which looked at the relationship between streaming and students' self-concepts, it was found that: "Moderate levels of regrouping may be beneficial for pupils' self-esteem, whereas higher levels of setting may be less advantageous." (p. 322). It was also reported in this study that while previous research had reported a negative impact of ability grouping on the lower groups, structured ability grouping may also have a negative effect on the upper-streams.

Loveless (1999) provides a very balanced look at streaming by ability. He recommends not moving too quickly with eliminating streaming because research has not far enough developed time-wise to verify any claims of benefits from eliminating streaming. He admits that moving towards mixed-ability classes seems to be showing that the gap between student performances is narrowing, but it seems to be at the expense of the higher achievers.

Kettler and Curliss (2003) suggest that while gifted and talented mathematics students are known to benefit from acceleration or advanced curricula, they can also excel in mixed-ability classes if the method of tiered objectives is used in that classroom. This means that "teachers can teach one concept to the whole class, while students develop knowledge and skills related to that concept at different levels of complexity." (p. 55)

MacIntyre and Ireson (2002) also give a middle perspective on the issue of ability grouping by suggesting that in-class grouping may have the effect of: "Raising attainment that avoids the social and emotional disadvantages of streaming." (p. 249)

Given that research has shown consistently over a long period of time that streaming does not really have a net effect upon achievement in mathematics and it seems to have an adverse sociological effect, it seems logical that alternatives need to be studied. This has been done by researchers over the years who have come to the conclusion that streaming cannot be eliminated without considerable planning and an

implementation phase. (eg. Slavin, 1996; Wheelock, 1992; Arbor, 2004). Indeed some have suggested that there are alternatives for improvement within the existing structures of streaming (eg. Gammoran & Weinstein, 1995; Ireson & Hallam, 1999).

Most would agree that if alternative plans are not put into place while re-creating heterogeneous classes, those disadvantaged by streaming may well be more disadvantaged in a mixed-ability class. Wheelock (1992) suggested several frameworks that could help the process. All students could be exposed to 'thinking' activities and group work instead of just giving them to the advanced students. Advanced teaching techniques and cooperative learning that caters for individuals could be used more for all groups of students. She also suggests that school-based resources could be distributed more to those who are struggling.

2.8 The Study of Student Attitudes to Mathematics

The purpose of the attitude dimension in this study is to use it as a means of comparative analysis to the core variables of the study which are the classroom environment scales. For this reason a short literature review on previous work done on student attitude to mathematics classes is given.

Tourangeau and Rasinski (1988) come to the conclusion that attitudes are structures that are resident in long-term memory and are dependent on this memory when they are expressed in surveys or in any other way. Respondents to attitude surveys first read the question and decide what attitude it is about. They then go to their long term memory to retrieve beliefs and feelings that may be relevant to that attitude. The next step is to apply those feelings and beliefs to the question at hand and make an appropriate judgement and then finally make their response. These steps are important to remember while reading this study because while the classroom learning environment inventory is collecting data on how students see the present climate of their classroom and how they would prefer it to be, the responses to the attitude survey are affected by the files the student has stored in their long term memory and may not be a property of the present classroom situation. Responses students make to specific questions on attitude surveys can also be dependent on previous questions. Previous questions can initiate some beliefs in the respondent making later questions either easier to answer or even redundant.

Student attitudes in mathematics may be dependent on a whole range of factors. Some attitudes stem from a 'love/hate' relationship with mathematics in the community in general. What their peers, parents and family say about mathematics may have an influence on their attitude. What has happened in their previous classrooms may also have had an impact on their attitude. The current mathematics classroom a student is a member of will also be having an effect on their attitude to the subject. Much of the research in learning environments has shown that attitude to the academic subject and learning environments are connected. For example in a thesis by Rickards (1998), a positive relationship between student attitudes and student-teacher interpersonal behaviour as a measure of perceived learning environment is reported.

Boaler, Wiliam and Zevenbergen (2000) discuss the idea of success in mathematics classes as more an issue of the student having a feeling of 'belonging' rather than an issue of 'ability'. Students may want to succeed at mathematics as a means to an end but they may have no desire to become 'successful mathematicians'. Boaler et al. (2000) also cast light on the importance of a nurturing learning environment in the mathematics classroom and how this learning environment can affect student attitude. The comment is made that the mathematics classroom becomes a "community of practice" where "learning is a social activity which encompasses the relations between people and knowing." (p. 4).

A group of trainee primary school teachers was interviewed on their feeling about mathematics. Cornell (1999) reports on the findings by saying that: "The students were nearly evenly divided between those who liked and those who disliked math. In nearly all the cases, a correlation existed between attitude and success." (p. 225)
This study by Cornell (1999) supports the theory that there are few neutral feelings about mathematics at school level. The study goes on to discuss some of the reasons for the negative attitudes towards mathematics. Teachers were said to be uncaring about students' lack of ability to do what was to them simple problems. Sometimes students believed they did not get the full explanation for doing a problem, leaving them frustrated. Students felt frustration at not being able to keep up with the rest of the class. They felt they were expected to rote learn but not taught for understanding. Most of the students interviewed by Cornell were very negative about tests and

examinations and how they contributed to increasing stress, decreasing self-esteem and generally disliking the subject.

Carter & Norwood (1997) studied the relationship between teachers' attitudes to mathematics and their students' attitudes to mathematics. They found that there was an obvious link between the two facilitated by the teaching and learning that went on in the classrooms. Given this link it seems that student attitudes to mathematics can improve if teacher attitudes improve. If teachers were able to move from a traditional approach to teaching mathematics which is better suited to the more able students, to a new and more constructivist approach to teaching, then students' attitudes across the ability range may improve. This philosophical move is an extremely difficult one for a teacher who has been teaching the same material in the same way for a long period of time.

According to Burns (1998), parents can also have a significant impact on a student's attitude to mathematics. He says that seemingly innocent words parents use sometimes at home such as 'I hate maths' or 'I was never any good at maths' can contribute to the students negative feelings about maths. They may only hear complaints about bank accounts not adding up or shop-keepers giving the wrong change. Rather they need to hear positive things or have their parent pick out everyday things that may have a mathematical application and talk to the child about it.

Utsumi & Mendes (2000) make the point that negative feelings towards mathematics tend to increase as the student progresses through school. They suggest that these feelings are probably due to the fact that their understanding of the concepts and content taught is decreasing as they progress in school. Turner et al (1998) add to this point by reporting that students commonly feel negatively towards mathematics classes when they become confused with how complicated the subject can be and the accuracy required.

Another factor said to affect the attitude of students towards mathematics is their own fear of the subject. Gilroy (2002) says that: "One of the problems is the fear associated with maths. Society puts such an emphasis on mathematics as an

indicator of intelligence that if students are not good at it, they feel a bigger sense of failure. They believe that they are not smart." (p. 40)

This study will seek to establish what the link is between student attitude to mathematics classes and the classroom learning environments in streamed mathematics classes. Sukhnandan and Lee (as cited by Venkatakrishnan & Wiliam, 2003) report a connection between streaming and student attitude, particularly in lower-stream students:

> Research suggests that streaming and setting, compared with mixed-ability teaching, have a detrimental effect on the attitudes and self-esteem of average and low-ability students. Research suggests that poor attitudes and low self-esteem can lead to a decrease in achievement which can create a vicious circle from which it is difficult for low-ability students to escape. (p. 195)

The instrument used in this study to survey students' attitudes to mathematics class is based on the Test of Science Related Attitudes (TOSRA) but modified to suit mathematics and highly condensed. Of the seven scales of 10 items each proposed by Fraser (1978), only the scale for 'Enjoyment of Science (mathematics) Lessons' was used.

2.9 Classroom Learning Environment Research

The concept of 'learning environment' has an array of meanings, but if applied to the classroom can be broken down into two elements. The first is the physical learning environment in terms of classroom furniture, displays, lighting, air quality and technology. The second is the psycho-social or human element to the learning environment which includes the behaviours and interactions of the students and the teacher within that classroom or school. The concept of a 'learning environment' will be the combination of these two aspects. A positive learning environment will be one that combines the positive psychosocial interactions within the classroom with a pleasingly aesthetic physical environment to provide a place where students can maximise their opportunity to learn. There have been studies that illustrate the connection between a positive learning environment and meaningful learning. (eg. Brophy & Putmnam as cited in Duke, 1979) There are also studies that examine the

association between physical learning environments and psycho-social learning environments. For example, Zandvliet (1999) made this connection when he studied networked computerised classrooms in terms of their physical or ergonomic learning environment along with the psycho-social learning environment.

Studies conducted over the last three decades have shown the association between student learning and the way students perceive their classroom learning environment (Fraser, 1994). This fact is what makes the study of learning environments vital and is a reason why learning environment research has become a specialised area which has contributed to improvements in classroom learning environments. (Anderson, 1982; Fraser, 1991; Fraser, 1998a; Fraser & Walberg, 1981).

Educational learning environment research has grown out of studies by Rudolf Moos (Moos, 1974) and Herbert Walberg (Anderson & Walberg, 1974). Before this Leary (as cited in Alden, Wiggins & Pincus, 1990) developed the concept of interpersonal theory (O'Connor & Dyce, 1997) and introduced the idea of measuring personality and group interactions using a circumplex scale. Leary in 1957, developed dimensions of interaction, or reflexes of interaction as a precursor to the *Questionnaire on Teacher Interaction (QTI)* which is based on the circumplex model. It seeks to measure student and teacher interaction. (eg. Wubbels & Levy, 1993; Fisher & Rickards, 1998; Rickards, 1998).

A landmark study by Welch and Walberg (1972) studied the impact of a new program for teaching Physics. This program was called the *Project Harvard Physics* and was undertaken to address the decreasing numbers of 'middle intelligence' students selecting Physics as a subject in senior school. Among the several tests and inventories that made up this study, learning environments were measured using the *Classroom Learning Environment Inventory (CLEI).* Welch and Walberg (1972) reported that the results were significant to the extent that the learning environments under the new program were perceived by the students to be more diverse and less difficult than the traditional program.

The majority of the early research into classroom learning environments was for the purpose of establishing relationships between the nature of the classroom

environment and the student outcomes measured, mostly in terms of achievement (Wong, Young & Fraser, 1997). It seems that in the past: "This research has revealed that students' classroom environment perceptions account for appreciable amounts of the variance in student learning outcomes, often beyond that attributable to student background characteristics." (p. 450)

Some of the implications highlighted by Wong, Young and Fraser (1997) that have been discovered historically with classroom environment measurement are:

(a) The size of the class can have an impact on the nature of the classroom environment. (Anderson & Walberg, 1972)
(b) There are differences between teachers and students in how they see their classroom environment. (Fraser, 1984)
(c) Classroom environments have been found to differ between Catholic and Government schools. (Dorman, Fraser & McRobbie, 1994)
(d) The achievements of a class can be improved by altering a classroom environment to be more in keeping with student preferences. (Wong, Young & Fraser, 1997)

Some useful outcomes of classroom learning environment research have been:

(a) Teachers have shown an interest in classroom learning environment research to the extent that they have used it to try and improve their own professional practice. They base it on five steps: assessment of *actual* and *preferred* environment; feedback; reflection and discussion, intervention; and reassessment. (Fraser & Fisher, 1986)
(b) Ideas gleaned from classroom learning environment research have been incorporated into teacher assessment. (Heroman, Loup, Chauvin, & Evans, 1991)
(c) Ideas gleaned from classroom learning environment research have been incorporated into teacher education. (Fisher & Fraser, 1991)
(d) The combination of qualitative with quantitative methods in learning environment research has been adopted. (Fraser & Tobin, 1991)

(e) Ideas gleaned from classroom learning environment research have been incorporated into school psychology. (Burden & Fraser, 1993)

Given the importance of the classroom learning environment to student learning, it is vital to consider what makes a 'good' learning environment. The challenge for teachers is that a good learning environment is not easy to develop and takes time and skill. Sometimes it may be perceived as easier to just keep doing what has been done for years.

Rover (2005) supports this: "Creating an environment in which all students can reach their full potential is one of those goals that is easier said than done. Sometimes even the best of intentions miss the mark." (p. 349)

Saunders and Kardia (as cited in Rover, 2005) attempt to define a positive classroom learning environment which they call an 'inclusive classroom'.

> Inclusive classrooms are classrooms in which instructors and students work together to create and sustain an environment in which everyone feels safe, supported, and encouraged to express her or his views and concerns. In these classrooms, the content is explicitly viewed from the multiple perspectives and varied experiences of a range of groups. (p. 1)

As the importance of learning environment research has been realised, different types of questionnaires to measure classroom environments have been developed. Chua, Wong & Chen (as cited in Fisher & Yang, 2000) report that learning environment measurement over the last couple of decades has been for four main purposes. Firstly it has been to establish a connection between the classroom climate and the outcomes of the students. Secondly classroom environment dimensions have been used as criterion variables to evaluate curriculum, courses and programmes. Thirdly it has been used to discover whether students achieve better in their *preferred* classroom environment. Finally it has been useful to implement different techniques highlighted in research to improve classroom learning environments.

Any history of classroom environment inventory research will give reference to two early instruments: the *Learning Environment Inventory (LEI)* (Walberg & Anderson, 1968) and the *Classroom Environment Scale (CES)* (Trickett & Moos, 1973). Later instruments were based on these two surveys. *For example My Class Inventory (MCI)* (Fisher & Fraser, 1981) was derived from the *LEI*. Some instruments were developed that were specific to certain subjects such as Science. *The Science Laboratory Environment Inventory (SLEI)* (Fraser, Giddings & McRobbie, 1995)

The instrument used for this research is the *What is Happening in this Class? (WIHIC)* (Fraser, Fisher & McRobbie, 1996). This instrument: "Was developed for use in any classroom environment context. It combined the best features of the existing instruments and included new dimensions of contemporary relevance." (Chua, Wong & Chen, 2000, p. 367). This instrument was originally a 90 item survey with 9 scales but the version used in this study saw the original edition reduced to 56 items with 7 scales. Another reason for using the *WIHIC* in this study was that it has available an *actual* form and a *preferred* form. This method of allowing the students to give accurate perceptions of their current learning environment but also their ideal learning environment, allows the researcher to measure the discrepancy between the two. Fraser and Walberg (1991) reported that students perform better and are more likely to achieve their academic goals when learning in an environment that is more closely aligned to their preferred classroom learning environment. This information makes it worthwhile and practical to have students complete both forms of the survey.

A summary of the nine major instruments used in the assessment of the classroom environment is given by Fraser (1998) and is best illustrated in a table (Table 2.3) similar to the one produced by Fraser (1998a) which categorised inventories by target group to be surveyed and by the scales first identified by Moos (1974).

Studies have been undertaken that use a combination of one or more of these instruments. For example, Henderson, Fisher and Fraser (2000) report on a study that used both the *Questionnaire on Teacher Interaction (QTI)* and the *SLEI (Science Laboratory Environment Inventory)* in one survey to: "Investigate associations between students' perceptions of their biology teachers' interpersonal behaviour and

their laboratory learning environments and their attitudinal, achievement and performance outcomes." (p. 26) The outcomes of this study showed that desired classroom learning environments were more positive than the students' current perceptions of their learning environments and that these discrepancies were largely due to the same scales that other studies had found were most significant.

As research into learning environments develops further, new learning environment instruments are being developed and trialled and existing instruments are being modified to cater for new areas of research. A recent example is a comparative student version of the *Constructivist Learning Environment Survey* (CLES-CS) which has been developed by Nix, Fraser and Ledbetter (2005) to: "Evaluate the impact of an innovative teacher development in school classrooms." (p. 109).

A new scale for measuring students' attitudes to learning mathematics with technology (*MTAS*) has been developed by Barkatsas (2005) and was presented at the 28th Annual Conference of the Mathematics Education Research Group of Australasia in 2005. This survey is designed to measure the attitudes of middle secondary students using five variables relevant to the learning of mathematics with technology.

As well as new instruments being developed to monitor current situations, current instruments are used to monitor new situations. A recent example of this is reported by Nijhuis, Segers and Gijselaers (2005) who used a combination of the *Random Course Experiences Questionnaire* (Wilson, Lizzio & Ramsden, 1997) and the *Biggs Study Processes Questionaire* (Biggs, 1997) to evaluate the depth of learning being experienced by a changed learning environment.

Given that one school of thought indicates that streaming can, from an early age, condemn a student to a non-academic future (Arbor, 2004), it may be helpful to look at research that zeros in on teachers of elementary schools and their attitudes to streaming. What sort of learning environments are they trying to foster? Elementary teachers are equivalent to Primary teachers in Australia and teach ages 5-12 years approximately.

Table 2.3

A Summary of Learning Environment Inventories

Instrument	Level	Scales Classified According to Moos' Scheme		
		Relationship Dimensions	**Personal Development Dimensions**	**System Dimensions**
Learning Environment Inventory (LEI)	Secondary	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Goal Direction Disorganisation
Classroom Environment Scale (CES)	Secondary	Involvement Affiliation Teacher Support	Task Orientation Competition	Order Rule Clarity Teacher Control Innovation
Individualised Classroom Environment Questionaire (ICEQ)	Secondary	Personalisation Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	Primary	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	Higher Education	Personalisation Involvement Student Cohesion Satisfaction	Task Orientation	Innovation Individualisation
Questionaire on Teacher Interaction (QTI)	Secondary	Leadership Understanding Helping/Friendly Freedom/ Responsibility Uncertain Dissatisfied Admonishing Strict		
Science Laboratory Environment Inventory (SLEI)	Upper Secondary Higher Education	Student Cohesiveness	Open-endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Secondary	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation
What is Happening in this Classroom? (WIHIC)	Secondary	Student Cohesion Teacher Support Involvement	Investigation Cooperation	Equity Task Orientation

Adapted from Fraser (as cited by Gabel, 1994)

A study by Ansalone and Boafora (2004) asked teachers several questions about streaming and came to the conclusion that in the majority of cases the teachers were still committed to the idea of grouping by ability. They point out that teacher expectations in the classroom have been found to be central to student achievement: "There is ample evidence to support the conclusion that the structure of the classroom could very well limit the academic achievement, and career trajectories of students." (p. 250) (Ansalone, as cited in Ansalone & Boafora, 2004; Hallinan, 1994, as cited in Ansalone & Boafora, 2004). Historically we find that: "Educational psychologists have identified the role of teacher expectations and instructional prejudices to help explain documented educational gaps." (Rosenthal & Jacobson, 1968, p. 18)

In the study reported by Ansalone and Boafora (2004), teachers were asked questions about their own experiences with streaming, about the advantages and disadvantages of streaming, about their attitudes to streaming the gifted, about equal opportunities to learn, and the effect on student self-concept. The results indicated that despite the teachers' own experiences with streaming and despite the amount of research available, teachers were not sufficiently concerned about classroom environments in streamed schools to 'vote' against them. They were most likely influenced by the ease of teaching for themselves in homogeneous groups and the likely risk to student learning if they, as the teacher, had little or no experience with teaching "large classes of diverse learners." (p. 254)

In a thesis by Rawnsley (1997) where he specifically looked at the classroom learning environment of mathematics classrooms, he discovered that: "The association between students' perceptions of their mathematics learning environment and attitudinal outcomes was stronger than the association with cognitive outcomes." (p. 154) He also reported that: "The greatest cognitive gains were found to be associated with teachers who displayed minimal dissatisfied behaviour and who gave their classes minimal responsibility and freedom." (p. 154) This research illustrates the fact that the classroom learning environment in mathematics classes is linked to learning outcomes. Understanding the impact of classroom learning environments on academic performance highlights the need for further study in this area.

English (1998) decided that students themselves would provide the most useful feedback on what sorts of mathematical tasks would most engage students. She says:

> Worthwhile mathematical tasks are generally considered to be those engaging students' intellect, capturing their interest and curiosity, developing their mathematical understanding and reasoning processes and allowing for different solution strategies, solutions, and representational forms. (p. 67)

Anonymous (1998) reports on David Drew of Claremont Graduate School who believes that children who are labelled as being bad at mathematics will end up performing badly. "He treated his students like winners, and they achieved higher scores in maths." (p. 17) He believes that a student's performance is directly related to the expectations placed on them. He referred to a study in which a minority group was given extra special treatment to see how they performed:

> When the African-American students participated in a workshop that introduced high expectations, long study hours, work groups, and extra homework –elements of the Chinese students' success – the study showed that they actually outscored white and Asian counterparts. (p. 17)

The study of constructivist learning environments and the use of the *Constructivist Learning Environment Survey (CLES)* has been an area of research over the last decade that studies critical theory perspectives alongside learning environments. Taylor, Fraser and Fisher (1997) give an account of the studies that proved this instrument to be robust in terms of: "Internal consistency, factorial validity and cross-cultural integrity." (p. 1). Though this study looks at classroom environments for the purpose of comparing lower-stream students' perceptions with those of upper-stream students, there is no doubt that if the objective were to study teacher transformations of a constructivist nature, the *CLES* would be the instrument to use.
Recent developments in the areas of mathematics and science education would look to new ways of helping students to develop at a conceptual level. Instead of scales relevant to the average classroom as used in the *WIHIC* (*student cohesiveness, teacher support, task orientation, involvement, investigation, cooperation and equity*), the *CLES* uses scales that measure epistemological innovation of the teacher

(personal relevance, uncertainty, student negotiation, shared control and critical voice).

Dorman, Adams and Ferguson (2002) studied the relationship between classroom environments and self-handicapping. The results of this study showed that there was a significant relationship between the classroom environment scales on the *WIHIC* and the extent of student handicapping. The scales on the WIHIC did in fact account for a greater proportion of the variance in self-handicapping than did the scales of the *Constructivist Learning Environment Scale* (*CLES*). This indicates that a good conventional classroom is more likely to lead to academic efficacy than a constructivist learning environment. (Ferguson & Dorman, 2001).

2.10 Learning Environments – Differences by Gender and Culture

2.10.1 Differences by Gender

The contrast between the way males and females learn mathematics has been the subject of research for many years (Leedy, LaLonde & Runk, 2003). The perception, supported by research, has been that mathematics is more of a male domain. Research conducted by Leedy, LaLonde and Runk (2003) of students who were particularly talented at mathematics showed that: "Traditional gender-based differences in the beliefs regarding mathematics persist even in these mathematically talented students." (p. 285) It was a finding from this study that much of the gender differences in approach to mathematics comes from deep set opinions or beliefs held by the students' parents and teachers. Erickan, McCreith and Lapointe (2005) investigate the same area and come to similar conclusions that the attitude of parents has the greatest impact on the attitude of girls, in particular, to mathematics. They conclude that: "Parents education level, a socioeconomic related variable, was one of the strongest predictors of participation for Canadian female students." (p. 5)

Previous studies (Martin, 2003) have shown that boys and girls are different with regard to their attitude to classes and their approach to their school related studies. Martin showed that girls are more positive than boys with regard to: "Their belief in the value of school, learning focus, planning, study management and persistence." (p. 44) At the same time the boys were found to be more willing to sabotage their own opportunities. The qualitative part of the study showed that boys have higher

expectations of their learning environments. They want better relationships with their teachers. They want to have strong and fair teachers who value their input and they want their schoolwork to be interesting and relevant.

A study conducted by Tocci and Engelhard (1991) looked at American and Thai students' relationships between attitudes toward mathematics and mathematics achievement. The study controlled achievement and parental support and still found there were significant differences in gender attitudes. Both Thai and American females had a more positive attitude towards mathematics when all other variables were controlled. A study by Goh and Fraser (1998) of teacher interpersonal behaviour, classroom learning environment and student outcomes in primary mathematics classes in Singapore reported that boys showed better levels of achievement than girls but the girls had a more positive view of their learning environment than the boys.

2.10.2 Differences by Language

Schools in Australia are in many cases – particularly in the cities – having to come to terms with an increasingly diverse student population. Teachers have to learn to cope with the integration of students with special needs in many areas. One of the most frustrating areas for teachers and students is coping with the second language students' needs in the classroom. As Buchanan and Helman (1993) point out, in the mathematics class the second language student must: "Learn in a linguistically and culturally unfamiliar environment, constructing understanding without the background knowledge that their classmates employ to make assumptions and process new information." (p. 1) They go on to say that it is necessary for there to be a moving away from traditional teacher approaches and more into the integration of literacy teaching and mathematics teaching side by side.

The types of tasks that may benefit literacy students doing mathematics will also benefit the rest of the class. Buchanan and Helman (1993) set out the steps necessary for this to happen. First mathematical activities have to be chosen that will challenge and interest the student. Just because their language skills are very low does not mean their mathematics skills are underdeveloped. Secondly the classroom activity must then create discussion and investigation. Thirdly computers and other

technologies must be used as often as possible to foster investigation. Fourth the teachers must try and find out the level each student is at and create links for that student between what they know and the new work they are doing. Fifth the teacher must also try to use a variety of instructional settings in the classroom. Small group work in particular will expose the literacy student to other students' language as well as the teacher's, which is beneficial to their literacy development.

According to Chamot, Dale, O'Malley and Spanos (1992), while learning conversational English for new students from overseas may only take around two years, learning English sufficient for the study of academic subjects takes more like five to seven years. Chamot et al. (1992) reported on a study that showed how innovative teachers (called *high implementation* teachers) brought about the more successful teaching of an assessed skill than the low implementation teachers. This adds weight to the notion that literacy students need variety and innovation to learn mathematics and value their educational experience in Australia. Chamot et al. (1992) also suggest that the teaching of academic language in ESL classes is another way to help the literacy students in their academic subjects. If this was done with the language of mathematics it may help the perception of international students of their mathematics classes.

There have been studies done to help mathematics teachers to better cope with literacy students in their classrooms. Anonymous (2001) presented some 'Classy Tips' for this purpose. One such tip was to pair literacy students with English speaking students as study partners so they can help each other with language as well as mathematics. Another idea put forward by Carroll (1996) is to ensure that literacy students get enough time to finish set tasks and examinations. Providing equal time for all students is not providing equity.

This study examined the differences in classroom learning environments experienced by different groups within a classroom. One such group is the students who come from overseas and do not have English as their first language. Planas and Gorgorio (2004) report research which shows that in our societies of today students from overseas account for the highest rates of failure at school. This rate becomes even worse when mathematics is considered alone. This is a concern because traditionally it would seem that mathematics has the least use of the English language and so

students should perform better in mathematics. According to Planas and Gorgorio (2004), one of the reasons for this discrepancy is that students from any type of minority group: "Experience difficulties when trying to participate in contexts of mathematical practices where they do not feel themselves represented, when others do not recognise them, or when they have to cope with actions and behaviours that are different from those they would expect." (p. 16) Planas and Gorgorio (2004) observed in classrooms that though the teacher may have the very best of intentions and may believe that they run an inclusive classroom, immigrant students' ideas were observed to be less valued than the ideas of the local students by the students and the teacher.

As much as students in schools who do not have English as their first language may feel isolated and frustrated when trying to learn mathematics in an English speaking country, secondary teachers struggle with the practicalities of providing the best environment for these students to learn in. In a study conducted by Reeves (2006), it is reported that: "Although the findings reported here suggest that teachers want to welcome ELLs into the mainstream, the data also reveals a teaching force struggling to make sense of teaching and learning in multilingual school environments." (p. 139)

2.11 Combining Qualitative and Quantitative Research Methods

For many years positivist research methods have taken precedence over any other method of data collection. Quantitative data has been seen as objective and easily analysed. (Erickson, 1998) This has also been the case with learning environment research where perceptions of teachers or learners has been collected from surveys in numerical form ready for statistical analysis. The use of qualitative data in the form of interviews, observations and focus groups has been introduced into learning environment research (Tobin, Kahle & Fraser, 1990) and has proved to be extremely useful in adding understanding to the numerical data obtained as well as opening up new insights into the way the participants in a classroom see their environment and why this is so.

It is evident that using a combination of qualitative and quantitative research methods in educational research has become popular and serves a distinct purpose

(Fraser, 1998). The use of qualitative data can complement and also add to the data gathered by using quantitative methods. In the first case, it may be possible to ask interview type questions that may not be possible to ask in a way that can be quantified. A narrative response may highlight an aspect of the research that could not otherwise be isolated. In the second case the interview can be used to expand on or explain things that are shown as significant using the quantitative research tool. In either case there is a strong argument for using both types of data in humanities type research. (Johnson & Onwuegbuzie, 2004)

It appears to be responsible reporting of research to go beyond the: "sterile dead end of checklists for 'effective' practice and the limited approach of method or technique-led research." (Nixon as cited by Barkatsas, 2005). The researcher can then: 'See individuals as living storied lives on storied landscapes." (Clandinin & Connelly as cited in Barkatsas, 2005).

Rickards and Fisher (1999) stated: "The combination of qualitative and quantitative methods in science and mathematics education research has provided a new direction to the way we examine schools and classrooms today." (p. 2)

Their example of combining the two types of data collection was at the time when the Questionnaire on Teacher Interaction (QTI) (Wubbels & Levy, 1993; Fisher, Fraser & Rickards, 1996) revealed differences in male/female perceptions of classroom environments and also how interpersonal teacher behaviour is associated with student attitudes. Using interviews of key informants made it possible for the subjects of this research to expand on trends that were obvious in the quantitative data. The result was that: "The quantitative data thus suggested that females perceived the classroom learning environment more positively than did males. This was also supported by the interview data." (p. 16)

Using both quantitative and qualitative data makes it possible to use the best aspects of both types of data collection. Supporters of each side of the debate over which type of research method is more appropriate have compelling arguments. Supporters of quantitative methods believe they are dealing with fact and leaving any biases out of the scenario. Qualitative researchers believe that it is impossible to leave out

biases and that researchers should use the value-laden aspect of qualitative data in order to 'tell the whole story'. Johnson and Onwuegbuzie (2004) believe that using both types of research together (mixed methods) is worthwhile. The weaknesses of each method can be left out while the strengths of each method can be capitalized on. Qualitative data can complement and help answer phenomena or anomalies that may arise from quantitative data. Johnson and Onwuegbuzie (2004) also point out that: "Mixed methods research offers great promise for practicing researchers who would like to see methodologists describe and develop techniques that are closer to what researchers actually use in practice." (p. 15)

Another advantage of mixed methods research is that it helps bridge the gap between researchers from each persuasion and will hopefully help their work to complement each others. It is also a distinct advantage that a researcher who can legitimately see the benefit of both data collection methods in their research, will be able to use both methods and have them work together.

2.12 Summary

In this chapter, the literature has been reviewed in the following areas: types of mathematics classroom (2.2), an introduction to streaming (2.3), the effects of streaming on learning (2.4), the organisational implications of streaming (2.5), the sociological effects of streaming (2.6), intermediate positions on streaming (2.7), alternatives to streaming (2.8), attitudes to mathematics (2.9), classroom learning environments (2.10), differences by gender and language (2.11), and an introduction to combining quantitative and qualitative research methods (2.12).

The following chapter will discuss the methodology used in this study.