LEARNING STYLES IN SECONDARY MATHEMATICS CLASSROOMS

Stephen Keast
Monash University
<Stephen.Keast@education.monash.edu.au>

A small rural school introduced single-sex classes in an attempt to increase the participation rates of girls in highest level mathematics classes at the senior level. The study revealed differences in the learning styles of the students. This led to the adoption of a new construct to evaluate the single-sex classes. This construct offers suggestions in the way mathematics classes could be conducted in high schools to assist students with non-traditional learning preferences.

BACKGROUND

The impetus for the study was the lack of participation of girls in senior mathematics classes which was of concern to the mathematics staff. Single-sex classes were thought to be a viable intervention strategy to assist the girls and to bring the issue to the attention of other staff, parents and the community. The school, upon which this study was based, is situated in a mostly cereal grain farming community in Western Victoria. Two similar nearby towns (in terms of demography and population) and a larger regional center acted as feeders for the school. The area is very conservative in its thinking, both politically and socially, and issues such as gender equity and affirmative action needed to be handled delicately. The science teachers at the school had been part of an extended science Professional Development program in 1994 to investigate ways to make the science curriculum more accessible for girls. At an inservice day in that year, attended by the mathematics coordinator (also a science teacher), the discussion focused on single-sex mathematics and science classes as a possible intervention strategy to encourage more girls to participate in senior classes.

When this idea was first proposed there was general opposition to single-sex mathematics classes by other staff. Their main objection centered on the idea that in single-sex classes girls would develop skills in a comfortable environment where they wouldn't need to compete with boys for the teacher's attention. The contention was that this would make the girls weak and unable to cope or relate with boys in their other classes. However, the school had been conducting single-sex Physical Education classes for about 10 years. These were defended staunchly by the staff and yet single-sex mathematics classes were viewed negatively. So it was in the face of firm opposition that in 1995 the single-sex mathematics classes started on a week by week trial basis in Year 8. This opposition prompted the author to conduct research for a Master of Education degree on the introduction of these classes, data was collected from the Year 8 classes in 1996 (see Author, 1998a). There were 3 class groups in the study, at Year 8 level, one mixed-sex class (MS, n=23), one single-sex girls class (SSG, n=22) and one single-sex boys class (SSB, n=21).

THEORETICAL FRAMEWORK AND PREVIOUS RESEARCH

This study was based on similar studies (Fuller, 1995; Morrow, 1991; Rowe, 1988; Rowe, 1990) which investigated differences in self-confidence in mathematics and mathematical achievement as possible causes for the lack of participation of girls in senior mathematics classes. The framework predicted that an increase in self-confidence in mathematics would lead to increased participation for girls in senior classes. The study included a mathematics attitude questionnaire (an adaptation of the Fennema-Sherman Mathematics Attitude Scales, Fennema & Sherman, 1976) and a set of parallel mathematics achievement tests (PATMATHS Test 2A and 2B, ACER, 1984). [1] Field notes were collected from discussions between the researcher and students, teachers and parents. No formal interviews were conducted, though some notes were collected from conversations had at Parent-teacher interviews and from mathematics faculty meetings.

As the research was being conducted it emerged that the initial construct was not a particularly useful lens in which to view the outcomes and findings. This was partly due to the fact that no increase in self-confidence was measured for any of the classes, while there were significant increases in mathematical achievement for the single-sex classes. Further discussions with the classroom teachers revealed particular behavioral traits well worth investigating. There also appeared to be serious conflict with the results of the attitudinal survey and discussions with the students, particularly the girls. While the survey results found a slight decrease in the self-confidence of girls, their general behavior and interest in mathematics demonstrated higher levels of self-confidence. Anecdotally, students wanted to talk about the positive experiences they were having in the single-sex classes, particularly the girls. In these discussions they were confident to talk about and discuss their mathematics and the events that happened in class. Concerns arose over the reliability of the scale to measure the level of self-confidence compared to the behaviour and comments of the students. The students' perceptions of themselves may not be consistent across all of their experiences, thus answers on the survey may reflect their long term attitudes towards mathematics, even though they enjoyed their experience and felt more confident that year. While they enjoyed mathematics in that year, their longer-term perceptions of mathematics study and their longer term intentions to study it may not have changed.

The work by Gilligan (1982), Belenky, Clinchy, Goldberger, & Tarule, (1986), offered a useful framework for analyzing these issues and offered a different lens through which to view the research data. Building on the moral reasoning proposed by Gilligan (1982), Bleneky et al (1986) suggest a framework for not only the way people reason, but the way they build knowledge and construct understanding. These authors proposed that people may have two distinct reasoning and learning styles at the procedural knowledge level based upon different perspectives and rules. *Separate Knowers* develop their knowledge separately from others, using a set of impersonal rules, through which they objectively and critically sort given information filtering out any subjectivity. These people exclude feelings and personal beliefs to develop their knowledge objectively. Their learning attempts to separate the knowledge from the source of knowledge so as to evaluate the knowledge itself.

Connected Knowers develop their understanding from the perspective of the knower. These people prefer to connect with the knower and try to understand her/him and their subjectivism and the way they formed their knowledge as well as their knowledge. These individuals trust knowledge that comes from personal experience rather than being handed down from authority. They value learning and knowledge that is woven into their personal relationships, surroundings and environment. These people do not try to view knowledge as cold and impersonal but try to include the emotion and personality of the knower and see this as adding to the knowledge rather than detracting from it. Their knowledge of truth develops through care for others and their relationships with others (for a more complete explanation see Belenky et al., 1986)

Buerk (1985) describes how these forms of knowing (Gilligan, 1992) can be used to explain the way people from each group develop their mathematical thinking and learning. Separate knowers prefer to develop their mathematical knowledge from an objective, individual and critical perspective. They prefer to learn their mathematical understanding individually from an authoritative perspective, critically analyzing the information supplied via formal, structured and explicit instruction. Ideas need to be fully developed and thought through before separate knowers are prepared to discuss them. Hypothetical and tentative talk is not a preferred method of forming and evolving their thoughts. Connected knowers value the knowledge of others that is based upon their personal and particular understanding and grounded in first hand experience. Relationships both between the learner and knower and the knower and their own knowledge are seen as important, almost essential for the development of new knowledge. Discussions are important to connected knowers and the forming of knowledge may often occur through tentative and hypothetical talk between learner and learner or learner and knower. It is the form of the knowing that is central to connected knowers rather than the content, (Buerk, 1985).

Traditional mathematics teaching is based on an authoritative figure (usually the teacher) giving out information in a non-contextual way without relevance to the life of most of the students. Learning is based on remembering and correctly applying often complex and unconnected algorithms. The examples, exercises and problems used are usually contrived and bear no relevance to or reflect few of the issues relevant to young people. Mathematics classrooms are predominantly arranged in ways that encourage students to work individually. The opportunity to discuss and talk through issues to form knowledge is often rare. Students often get the feeling that mathematics classrooms are different to their experiences in other subjects. In mathematics classrooms the answers are always known and this offers students little opportunity for creativity and discovery. Such a view of mathematics classrooms suits the preferred learning style of separate knowers but is in contrast to the preferences of connected knowers. Teaching in a connected way includes:

- giving students the opportunity to find their own voice;
- have first hand experiences with mathematics;
- have the opportunity to pose their own problems;
- experience doubt in their understanding that requires questioning of themselves and reaffirming their belief in themselves;
- have support through challenging phases without being given answers; and,
- being given the opportunity to explore within the curriculum.

(see Becker, (1995), and Buerk, (1985)).

THE CONTINUING INVESTIGATION

Not long after the single-sex classes started in 1996, the researcher was in discussion with the teachers about the classes when it was revealed that there were differences in the attitudes and behaviours of the students. At this stage the researcher was not aware of the notion of connected and separate knowing. Generally, the boys in the SSB class preferred to work individually, they disliked group work and were not inclined to share ideas. They preferred learning from the board with the teacher as a transmitter, giving out information for the students to receive. The students in this class clearly preferred to learn as separate knowers. In the SSG class the students formed small groups at every opportunity, shared ideas and discussed their learning. They preferred group work to direct instruction and enjoyed and appreciated the opportunity to investigate problems beyond the more trivial applications associated with "normal" bookwork. The following discussion highlights this point:

> The assistant-principal (AP) took an extra of the SSG class in 1997, and came away surprised by what he saw. ... The AP commented that the girls had talked a lot in class but the talk was about the mathematics and sharing their ideas and solutions to problems. He was surprised he didn't have to continually return them to task. There was a pleasant working atmosphere in the class, they seemed to work through their difficulties by seeking help from each other and they seemed to be enjoying their mathematics. He said it was different from other mathematics classes he had sat in on.

(Keast, 1998a, pp. 154-155).

In the following year 1997, teachers changed their teaching approach to accommodate the connected knowing preference of the girls' class. The emphasis was on group work and sharing knowledge; as this appeared to be preferred by most girls.

The Students' Perspective

The girls who in the past had not experienced a lot of success in their mathematics class were more at ease in the single-sex class, they didn't feel as "lost" as before and were more willing to verbalize their mathematics in class, ask questions and share their ideas with other classmates. They appeared to improve substantially in their understanding and willingness to participate in class discussions. However, there was a small group of very able girls who objected to the methods being adopted in the class. Most of all they felt their superiority over the other girls was being undermined.

One able girl in 1997 said:

> Some girls who are really dumb at mathematics, now ask questions in class I don't know the answer to.

This had not happened before, the more traditional mathematics class, taught in a separate knowing way from the authority perspective had suited her well. She had a clear preference for separate knowing and did not like the idea of needing to change. Some girls appeared to prefer to learn in the separate knowing style rather than the connected knowing style that most of the girls exhibited.

One particular girl mentioned at Parent-Teacher interview that she felt the class had not covered as much work as the year before, and that therefore they had not learnt as much. The reasons she felt this way were based on the amount of group work covered and the lack of exercise books she had filled with practice problems! While skills practice remains an integral part of the course, many more classes are devoted to group development, sharing ideas and problem solving; this girl in particular did not view these as learning. Working in groups, discussing and developing ideas, was not as valued as copying copious quantities of notes from the board and learning algorithms to apply to set exercises. The main issue was the value placed on this style of learning by the higher achieving girls. This girl did concede that the SSG class had covered the same topics as the other class in approximately the same time. Also, she had achieved very good results in all her assessment pieces including tests. However, while she could agree that she had understood the work and the classes were enjoyable, she remained concerned as to her perceived level of difficulty of the mathematics being covered in the class. But her perceived level of difficulty was related to how difficult other students found it to understand.

> Mathematics should be hard, she said. We aren't doing enough work for a hard subject.

Her concerns about mathematics related not only to the amount of work she had completed, but to how hard it should be for *other* students to understand!

Towards the end of the first semester most girls favored the connected mode of learning compared to the separate mode, though the terms "separate" and "connected" were never mentioned directly in class. A small group of high achieving girls were not convinced that this was a better way to learn mathematics. What this highlighted was the fact that all the boys were content to be taught in the separate way without complaint, but not all girls were content to be taught in the connected way. Some of these girls operated as separate knowers, though none of the boys operated in the connected mode.

Teacher Perspective

From observation of the teachers' classes and from conversations with them the teachers found they changed their teaching methods to reflect the style preferred by the students.

The single-sex boys' class was taught in a very traditional and separate knowing way with the boys learning in a very individualized and independent way. In this class studentsresponded well to games and competition in their tasks, where the completion of the task required boys to work on their own. In the single-sex girls' class, it was observed that the girls formed small learning groups based on the tables where they sat. Their learning was a sharing process with lots of discussion and developing of ideas in a connected way. Whenever they were given the opportunity the girls would form small groups, discuss their learning and share their ideas. They always sought connection with each other. It was found to be too ineffective to teach the girls in the more traditional way. Boys in the single-sex class disliked group work and it was found to be very difficult to get boys involved in discussions of their understanding of mathematics.

School Dilemmas

It appears students prefer to learn via one of two learning styles. It is not clear if students alter their learning preference depending on the subject, time of day, or if this changes over time. Anecdotally some girls appeared to change from separate knowing to connected knowing over the course of the year. So, what are the implications for teachers in the classroom? If teaching is directed towards one method of learning (eg separate knowing) what is the impact on those students who prefer to learn via the other method (eg a more connected approach)? Teachers may need to view problem solving (and problem posing) activities, group work and discussion as important aspects of teaching for connected knowers rather than as required curriculum initiatives. Teaching mathematics has traditionally been taught in a way to encourage separate knowing and support separate knowers. This has alienated a large number of connected knowers (generally girls) who prefer to learn in a more connected way.

The unanswered questions the school staff and this researcher now grapple with are:

- Is it possible to identify which students operate in which learning mode and then group them accordingly, with their classes structured for their preferred learning style?
- What percentage of girls and boys prefer to learn as separate or connected knowers?
- Do students learn all aspects of mathematics according to their preferred learning style or can they swap between styles for different aspects of work and different subjects?
- Do students change learning styles for different classes, topics or over time
- Should those girls who prefer separate knowing in mathematics be taught with the boys?

These are similar to those issues raised by Morrow (1996).

CONCLUSION

There are two learning styles (separate and connected knowing) and two associated teaching styles (separate and connected teaching). There is anecdotal evidence that traditional mathematics teaching is mostly separate teaching. Separate knowers relate well to this style of teaching as it is representative of their preferred learning style. However, this style of teaching alienates connected knowers, who find it difficult to make connections with mathematics in these classes. Connected teaching with an emphasis on linking mathematics in the classroom to the students and their experiences encourages connected knowing students. But what are the implications of connected teaching on separate knowers? In this study it was difficult to encourage separate knowers (including some very high achieving girls) to participate in activities that encouraged connected knowing. However, over the course of the year some girls who began by preferring separate teaching had changed to preferring connected teaching by the end of the year.

From this study and the work of Morrow (1996) and Becker (1996) a different picture of mathematics teaching is starting emerge, where teachers encourage students to make connection with their own experiences and the experiences of others. Morrow (1996) contends that many connected knowers (particularly girls) in mathematics spend much of their time listening to the ideas of others. She suggests that if connected knowers are to gain a sense of their own voice in mathematics then teachers need to give them opportunities to verbalize their mathematics knowledge. It is through such discussion that students form, modify and develop their thoughts into ideas. For students who prefer to learn as connected knowers, the support of small groups and the role of hypothetical and tentative talk is important, almost essential, in the development of their ideas and understanding.

Such work is grounded in the ideas proposed by Belenky et al., (1986). To encourage more connected knowing in mathematics by both connected and separate knowers, topics need to begin from a context which provides relevance through real world application and needs. In order to promote appropriate student talk, this should be done in small groups to provide opportunities for students to interact and verbalize their understandings as they develop. The emphasis needs to be on problem solving and problem posing, with the teacher modeling the problem solving and posing process. Mathematics needs to be modeled as not always being completely known, but that there are alternative paths to the same solution, also that not all problems have neat and clinical solutions. In the real world many problems have no solutions, and approximations are required. Teachers need to show students that they make mistakes, take wrong paths, back track, create assumptions, analyze and evaluate their work, check assumptions, alter them and continue.

REFERENCES

ACER. (1984). *Teachers Handbook: Progressive Achievement Tests in Mathematics.* Camberwell, Melbourne: The Australian Council for Educational Research Limited.

Becker, J. (1995). Women's Ways of Knowing in Mathematics. In P. Rogers & G. Kaiser (Eds.), *Equity in Mathematics Education: Influences of feminism and culture* (pp. 163-174). London: The Falmer Press.

Becker, J. (1996). Research on Gender and Mathematics: One Feminist Perspective. *Focus on Learning Problems in Mathematics, 18*(1, 2 & 3), 19-25.

Belenky, M., Clinchy, B., Goldberger, N., & Tarule, J. (1986). *Women's Ways of Knowing: The Development of Self, Voice, and Mind.* New York: Basic Books.

Buerk, D. (1985). The Voices of Women Making Meaning in Mathematics. *Journal of Education, 167*(3), 59-70.

Fennema, E., & Sherman, J. (1976). Fennema-Sherman Mathematics Attitudes Scales: Instruments Designed to Measure Attitudes Toward the Learning of Mathematics by Females and Males. *Catalog of Selected Articles in Psychology, 6*(1), 31.

Fuller, A. (1995). *The Effects of Single-sex Classes on Students' Confidence and Participation in Mathematics.* Unpublished MEd, University of Melbourne, Parkville.

Gilligan, C. (1982). *In a Different Voice: Psychological Theory and Women's Development.* Cambridge, MA: Harvard University Press.

Keast, S. (1997a). *Single-sex Mathematics Classes - Who Benefits?* Paper presented at the Imagine the Possibilities: Thirty-fourth Annual Conference of the Mathematics Association of Victoria, Melbourne.

Keast, S. (1997b). *Teaching Mathematics for Girls and Boys Through Single-sex Classes.* Paper presented at the Mathematics Creating the Future: Sixteenth Biennial Conference of the Association of Mathematics Teachers, Melbourne.

Keast, S. (1998a). *Effectiveness of Single-sex Mathematics Classes at Murtoa Secondary College.* Unpublished MEd, Monash University, Churchill.

Keast S. (1998b). *Gender Issues and Single Sex Maths Classes.* Paper presented at the Mathematics: Exploring all Angles: Thirty-fifth Annual Conference of the Mathematics Association of Victoria, Melbourne.

Morrow, B. (1991). *Effect of Gender Segregation on Female Student Achievement and Attitudes in Year Eleven Mathematics*. Unpublished MEd, La Trobe University, Bundoora.

Morrow, C. (1996). Women and Mathematics: Avenues of Connection. *Focus on Learning Problems in Mathematics, 18*(1, 2 & 3), 4-18.

Rowe, K. (1988). Single-sex and Mixed-sex Classes: The Effects of Class Type on Student Achievement, Confidence and Participation in Mathematics. *Australian Journal of Education, 32*(2), 180-202.

Rowe, K. (1990). What are the Benefits of Single-sex Maths Classes? *Set, 1*(9), 1-4.

Endnote

[1] (For a brief discussion of the outcomes see Keast,1997a; Keast, 1997b; Keast, 1998b. For a more comprehensive discussion of the outcomes see Keast,1998a).