Gender-inclusive mathematics: An illusion or reality?

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In the western world mathematics in education has been traditionally viewed as a masculine area of knowledge and expertise. In more modern times girls and young women have been assimilated into this male cultural domain of abstract and rational thought. This article examines this process of assimilation through feminist theoretical lenses to locate the current position of girls and young women in school mathematics: in the dynamics of the classroom and in the discourse of the Mathematics in New Zealand Curriculum document. This paper explores the extent to which the epistemology and pedagogy of the mathematics discipline has diversified to include the knowledge and experiences of women, to become gender-inclusive as required by the New Zealand Curriculum Framework.

Introduction

Fry (1985), a New Zealand historian, illustrates the 'naturalness' of differentiated experiences for girls and boys in the mathematics curriculum. She describes how girls were given needlework while '…boys were given extra arithmetic, a subject for which they were seen to have practical need and possibly greater aptitude' (p.14). The hidden messages of the power/knowledge relationship, as discussed by Paechter (2001) using post structural analysis, were masked by 'natural' gender differences in access to curriculum.

In the early twentieth century girls spent less time on mathematics and science than boys, making their entry into the higher reaches of these subjects extremely difficult. At the same time, this exclusion meant that subjects had stereotypically masculine characteristics reinforced (Paechter, 2001, p.28).

More recently, since the 1960s, feminist researchers and theorists have examined girls' place in mathematics. Feminist theoretical perspectives are wide-ranging and complex, reflecting the diverse groups comprising the feminist movement. The goal of all of these groups has been to promote gender-inclusive pedagogy.

In the mid 1970s liberal feminist theory identified gender inequalities in the curriculum. Its theories initiated notions of gender equality and non-sexist policies in education. Later, in order to challenge mathematical epistemology and to deconstruct the 'truth' about mathematics, feminists turned to critical and post structural theory. Critical theory focuses on the emancipatory interests of marginal groups whose intellectual and political voices are rarely heard. Radical and socialist feminism uses critical theory to examine and research gender issues in education policy and practice. Both critical and poststructuralist theory are concerned with the central question of what counts as legitimate mathematical knowledge, and who controls that knowledge.

Central to all theoretical discussions is the 'girl'. She represents a diverse range of people belonging to different socio-economic, class, ethnic and sexuality groups. Girls and young women comprise a wide-ranging group of learners of mathematics representing Maori, Pacific Islanders, Pakeha, Asian, European, working class, middle class, urban, rural, lesbian and heterosexual. In this paper the terms girls and young women are used universally, but with recognition of their diversity.

Patterns of gender differences observed – Feminist Perspectives

Liberal feminism

In the 1970s liberal feminism highlighted gender issues by pointing to girls' underachievement in school, particularly in mathematics, and by promoting equal educational opportunities for women and girls (Brickhouse, 1998; Williams & Sheehan, 2001). Weiner, Arnot and Davis (1997) note that in England from the 1940s until the early 1960s there was "relatively little discussion of gender and education, or of gender issues more widely" (p.623). Even toward the end of the 1970s policy-makers largely ignored feminist appeals for gender equality. "(T)he educational performance of girls was

generally interpreted in terms of their prime vocational destination as wives and mothers" (ibid. p.623). It was not until the early 1980s that liberal feminist theories were taken seriously, and interventionist programmes were established which included non-sexist careers advice, and curriculum access for all.

The liberal feminist critique was limited to issues of individual rights and equal opportunity, basic concepts of liberalism dating back to the late nineteenth century Age of Enlightenment (Giroux, 1997). Nowhere did liberal feminism "…challenge the fundamental social order nor the legitimacy of traditional gender relations" (O'Neill, 1992, cited in Williams & Sheehan, 2001, p.216). In its critique of education, liberal feminism constructed 'girls' as a unified category. It did not acknowledge that girls belonged to diverse groups, and in claiming equal access to academic institutions, did not challenge institutional structures.

Radical feminism

Critical theorists, such as Young (1975) and Bowles and Gintis (1976), assert that the process of schooling reproduces the class structure of capitalist society. During the late 1970s and early 1980s New Zealand's free, compulsory, secular, 'egalitarian' schooling system became an area of concern for researchers. Following overseas leads, inequalities were identified in access to and achievement in education for girls, working class, and Maori children. Using critical theory and more recently post-structural theory, feminist researchers took up these issues. Socialist feminism and radical feminism explored gender issues in education by examining the role of capitalism and the patriarchy in reproducing inequalities of class and gender through schooling.

By the mid to late 1980s education theorists were providing "…historical analyses of the early establishment of both a gender-differentiated curriculum and differentiated experiences for girls and boys" (Williams & Sheehan, 2001, p.216). Through the lens of socialist and radical feminism the differentiated experiences of girls and boys were based on perceptions of femininity and masculinity, and of biological determinism in which gender differences were seen as genetically determined and natural. Feminists critiqued

the historic common sense notion of ‘natural’. They argued that gender was socially constructed and that biological determinism is part of the hegemonic, patriarchal education system that marginalises girls and young women (Pihama & Mara, 1994).

The knowledge/power relationship is central to more recent poststructuralist feminist theory. This views knowledge as intimately connected with power; a relationship which is continually contested amongst individuals and small and large groups, in a multitude of public and private sites (Paechter, 2000).

Mathematics

1980s

Feminists identified the ‘maleness’ of the mathematics curriculum and pedagogy in the mid 1980s as being problematic. Classroom observation studies reported that neither teacher-language and behaviour, nor the physical environment, was conducive to encouraging young women to continue their studies in non-compulsory secondary school mathematics. To counteract this, it was argued that girls and young women would be more likely to succeed if ‘women’s ways of knowing’ underpinned mathematics discipline and pedagogy (Walls, 1997).

Becker (1995) researched ways to increase women’s participation in mathematics and mathematics-related careers by investigating and tutoring ‘connected ways of knowing’ and connected teaching methods, which incorporate collaborative, cooperative learning styles, and used constructivist learning approaches. Her concern was that “…if the way mathematics is currently taught alienates many women because it does not appreciate or validate their ways of knowing, then many women may choose not to pursue mathematics and mathematic related careers” (p.172).

Feminist educators saw evidence that girls were ‘dropping out’ at senior levels of study in mathematics because of their sense of alienation to the masculine nature of the subject and their inability to perceive the future usefulness of mathematics. This was problematic as not studying senior mathematics limited girls’ career choices in high status and

financially rewarding occupational fields. Willis (1995) saw "…a major function of mathematics … as a de facto intelligence test and consequently a filter between school and sometimes quite unrelated further education and occupation opportunity" (p.188). Advanced mathematics was seen not only to diversify career choice, but also to create opportunity for women's voices to be heard in a predominantly male field of expertise.

To address this situation and other identified barriers to girls' mathematical achievement, such as issues of confidence and the nature of interactions in mathematics classes, it was suggested by theorists, and taken up by policy writers, that classrooms become more 'girl friendly'. Teachers were asked to become more gender sensitive and to build up girls' confidence by incorporating girls' learning styles into their teaching programmes. Single sex schools were promoted as providing more effective learning, and extra tutorials or 'catch up' classes were recommended to remedy girls' underachievement (Baker, 1994; Yates, 1998).

1990s

By the end of the 1980s and the early 1990s feminist research was looking more extensively at classroom dynamics. The term 'girl' was deconstructed to include the diversities of class, race and sexuality. Observations of classroom dynamics indicated a general pattern of boys, through loud, disruptive and aggressive behaviour, gaining more negative and positive teacher attention than girls. Working from a socialist feminist perspective, Newton (1992 cited in Williams and Sheehan (2001)), posited that "…inequitable gender relations within wider social structures are reproduced and maintained by education institutions, that in mixed classrooms children learn and practice behaviours which prepare them for an adult world controlled and dominated by men" (p.217). Newton tested her hypothesis by observing morning talk sessions in mixed-gender classrooms. The findings confirmed that boys did gain more teacher attention and "…received positive reinforcement and 'rewards' for behaviour which is considered 'normal' for girls" (Pihama and Mara, 1994, p.238).

Measor and Sykes (1992, cited in Williams & Sheehan, 2001), observing power relationships between girls and boys, confirmed that boys not only gain the majority of the teacher's attention but in doing so promote their own interests. They tend to dominate or influence curriculum discussion and marginalize girls. Fergusson and Horwood (1997) report similar findings. In their longitudinal study of cohorts of Christchurch children, tracking their achievement through the school years from 1982 to 1995, they found that "males had significantly higher …rates of both conduct problems and attentional problems" …with these "higher rates of disruptive, inattentive behaviour in boys impaired male learning" (p.89 & 92). This disruptive behaviour in boys not only impaired boys' learning, it also had the potential to impair girls' learning. This confirms Williams and Sheehan's (2001) contention that "…boys have the power to reduce girls' chances of success at school" (p.215).

Evident in these studies of classroom dynamics is the role of the hidden curriculum in maintaining and reproducing gender inequalities. "Examples of the hidden curriculum in action are stereotypical messages about … gender roles which are transmitted through teacher actions, everyday occurrences in schools, and pictures and texts in resources/textbooks" (Carpenter, 2001, p.111). Views of girls in traditional mathematics are reflected in teacher expectations, teaching practice, classroom resources and texts, and in parent and societal expectations, or through the hidden curriculum. Using a post structural analysis, Walkerdine (1988) discusses the origins or pure, abstract mathematics as a male preserve dating back to the mid seventeenth century of 'rational enlightened thought', which traditionally excluded women and subtly still does "…as many women find it hard to position themselves as legitimate knowers" (Jones & Jacka, 1995, p.169; Walshaw, 2000). Walkerdine (1989, as cited in Gilbert 1999, p.18) contends that "…girls' high performance in mathematics is perceived not as the evidence of the possession of 'rationality', but as the result of their 'hard work', 'diligence' and/or 'rule-following behaviours'".

The notion of mathematics as a male domain prompted 1990s feminist researchers to question the legitimacy of mathematics as a discipline in its present form, with its

associated pedagogies. “Pedagogy is posited as central to any political practice that takes up questions of how individuals learn, how knowledge is produced, and how subject positions are constructed” (Giroux, 1999, p.18). Mathematical knowledge is a social construct (Young, 1975) and the validity of its hierarchy of abstract concepts was brought into question in relation to ‘women’s ways of knowing’ as an alternative way of constructing mathematical knowledge. Consequently, connected teaching methods and constructivist approaches that were aligned to women’s ways of knowing were added to curriculum content (Ministry of Education [MoE], 1993).

Policy documents

Most policy documents are underpinned by a liberal feminist focus on equal opportunity. This aims to ‘fix’ the girl (attitudes, confidence, ability) so that she can compete equally with boys. Other feminist foci, using critical and poststructuralist theory, promote changes to curriculum content, delivery and assessment procedures by advocating a gender inclusive mathematics curriculum.

Feminist work “…has transformed mathematical practice for girls: through new conditions which promote mathematical achievement, and a new self-consciousness about gendered experience” (Walshaw, 2000, p.145). In response to accumulated scholarly research, policy documents in mathematics published in the last decade claim to be gender inclusive and where applicable promote “…strategies that use the strengths and interests that girls bring to mathematics, e.g. cooperative learning tasks” (ibid. p.149). An example is provided in the foreword of the *New Zealand Curriculum Framework* (*NZCF*):

> … it is a gender-inclusive curriculum, which acknowledges and includes the educational needs and experiences of girls equally with those of boys, both in its content, and in the language, methods, approaches, and practices of teaching” (MoE, 1993, p.1).

Walls (1997) critiqued two Ministry mathematic documents; *Implementing mathematical processes in mathematics in the New Zealand curriculum* (MoE, 1995) and *Development band mathematics* (MoE, 1996) to ascertain whether they reflected the gender inclusive policy of *NZCF*. She notes that the first document is fully inclusive of girls' learning styles. The document's recommendations were:

> Changing the role of the teacher from 'chalk and talk' to 'guide on the side', advocating more extensive use of collaborative, open-ended dialogical and risk-taking learning experiences, and suggesting teachers allow for fair distribution of the nature and amount of teacher attention across the whole class and where it seems appropriate, bring the issue of gender in classroom interaction, through class discussion (Walls, 1997, p.6).

These recommendations are gender inclusive in that they promote effective teaching strategies for both girls and boys. This is compatible with the curriculum experiences in Freire's (1972) emancipatory pedagogy which hails the teacher as a facilitator and encourages learning to start with children's life experiences. Walls (1997) notes that the 1995 document was designed to "…present both gender and culture balance by way of photographs, illustrations, learning contexts and teachers own stories" (p.6). The document successfully promotes teaching/learning strategies that favour 'women's ways of knowing' without labelling or implying that girls need remedial attention.

In contrast, *Development band mathematics* (MoE, 1998) lacks gender inclusiveness. *Development band mathematics* is designed to assist teachers to identify children with special abilities in mathematics and to provide ideas for appropriate experiences to extend their learning. However, it demonstrates a gender bias towards boys. This starts with the photograph on the front cover which features a majority of 'active' boys and a few passive girls. Special abilities are equated with 'faster' students who can be identified by the following attributes: "…disruptive, uncooperative, resentful of authority, nuisance, show-off, leader, strong 'scientific' bent" (cited in Walls, 1997, p.6). These characteristics match the description of boys previously referred to in the discussion on

classroom dynamics. Walls (1997) points out that the test items suggested for identifying 'fastness' are mainly abstract problem solving which boys usually score highly on. She also makes the point that competent girls might go unnoticed; their studious nature means they appear to not require teacher attention. Walls (1997) concludes her observations:

> … (If) teachers are encouraged to believe that some children are naturally mathematically gifted and others aren't, children will take on this belief too. In a society, which already sends out potent messages about who are the winners and losers, it is not unreasonable to suggest that these beliefs will be replicated in the classroom. And guess who are likely to be the losers (p.7)?

It is interesting that this document appears to show bias towards boys as faster learners who are more likely to be identified with special abilities at a time when popular rhetoric is lamenting boys' under achievement at school. Further discussion on these issues is provided by Fergusson and Horwood (1997).

The Mathematics in the New Zealand Curriculum [*MiNZC*] (1992) document attempts to be gender inclusive but in doing so continues to marginalize and pathologise girls as disadvantaged (italics added, not in original document):

> …In many cases in the past, students have failed to reach their potential because they have not seen the applicability of mathematics to their lives and because they were not encouraged to connect new mathematical concepts and skills to experiences, knowledge and skills which they already had. This has been particularly true for many girls, and for many Maori students, for whom the contexts in which mathematics was presented were irrelevant and inappropriate. These students have developed deeply *entrenched negative attitudes* towards mathematics as a result.
>
> An awareness of these issues has led to *improved access* for girls to mathematics, but the participation rate of female students in mathematics continues to be lower

> than that of male students at senior school level and beyond. This *limits* later opportunities for girls and women.
>
> The suggested learning experiences in this document include strategies that utilise the strengths and interests that girls bring to mathematics. Techniques that help to involve girls actively in the subject include setting mathematics in relevant social contexts, assigning cooperative learning tasks, and providing opportunities for extended investigations.
>
> The suggestions also describe experiences which will *help girls develop greater confidence* in their mathematical ability. Girls' *early success* in routine mathematical operations needs to be accompanied by experiences which will help them *develop confidence* in the skills that are essential in other areas of mathematics. *Girls need to be encouraged* to participate in mathematical activities involving, for example estimation, construction, and problems where there are any number of methods and where there is no obvious 'right answer' (Ministry of Education, 1992, p.12).

The italicised sections demonstrate that the curriculum continues to depict girls as deficient. 'Treatment' is offered to help girls improve their mathematics achievement. By placing girls in a unified category there is no recognition of diversity amongst girls, or of their current equal achievement in mathematics with boys (Alton-Lee & Pratt, 2000).

Despite contemporary rhetoric that boys are now underachieving when compared with girls (Fergusson & Horwood, 1997; Gilbert, 1999), there is evidence that girls on average, over the last decade, are achieving at a higher level academically than boys (Gilbert, 1999; Jones & Jacka, 1995; Keef, (1990) cited in Walshaw, 2000). Notwithstanding this evidence, *MiNZC* treats girls as 'lacking', making invisible instead of publicly recognising girls' competence and success. Jones and Jacka (1995) observe that where girls' success is acknowledged it is then downplayed by their failure to pursue mathematics at non-compulsory and tertiary levels. The reality is that currently there are

fewer girls choosing mathematics as a career, and part of the reason is that many girls actively choose other career paths (Fennema, 1993).

By offering strategies which help girls 'measure up', *MiNZC* places them in the position of 'other' to boys who are deemed to be competent mathematicians. An example of this is shown in the last part of the curriculum statement which presents 'prescriptive packages' to help girls move on from solving single-solution problems; this implies that "…boys have confidence in multifaceted approaches and solutions; girls do not" (Walshaw, 2000, p.150).

Gilbert (1999) suggests that girls' differences should be celebrated and valued as worthwhile, instead of being compared to the 'other', described as the "…standard white, middle-class, able-bodied, urban, heterosexual male assumed in Western European political discourse" (p.14). For example, although associated with 'women's ways of knowing', cooperative tasks and contextual situational learning are highly effective learning strategies for all students. These should be an integral part of mathematics' pedagogy along with all other valuable women's knowledge. Situating women's knowledge as central to mathematics values girls as integral members of this discipline, rather than requiring them to be assimilated into a male domain.

Jones and Jacka (1995) discuss the use of discourse to construct the 'truth' about girls and comment on how "…mainstream discussion and policy texts on girls' achievement generate truths and prescriptions. They not only contain assumptions about 'what is the case'. They also create the 'case'" (p.168). The discourse of the curriculum document (MiNZC) describes girls as disadvantaged and in need of treatment, rather than celebrates their achievement. In Foucault's poststructuralist view this positions the girl as having to accept or reject the discourse in the document at her site of power struggle, the classroom. This view, with reference to *MiNZC* discourse, is elaborated below:

> With every moment of classroom practice the text is rewritten, as the girl re-presents the discourses at work in the classroom and uses them to formulate and

> articulate her own version of the world. In negotiating everyday school life, she will assume various positions in the discourses which offer possibilities for modification or difference (Walshaw, 2000, p.123).

Epistemology – towards the feminisation of mathematics

It appears that contrary to the *NZCF's* (1993) claim to a gender-inclusive curriculum, *MiNZC* has positioned the girl as 'needy' and requiring 'treatment'. In working toward a gender-inclusive approach *MiNZC* has made concessions to incorporate prescriptions of strategies and techniques that have stemmed from feminist research of women's knowledge, to widen the pedagogy from its original male perspective. *Implementing Mathematical Processes in Mathematics in the New Zealand Curriculum* (MoE, 1995), has achieved a gender-inclusive approach by promoting a change in pedagogy which expands mathematical thought from its traditional abstract nature to practical concepts initiating with the learner' experiences. This corresponds more closely with recent feminist literature as it does not portray girls as 'lacking'.

Throughout the 1990s feminist research has critiqued the construction of mathematical knowledge as a source of exclusion to women and other marginal groups. Traditional mathematics incorporates masculine 'ways of knowing', and centres on rational abstract thought, which descended from the Age of Enlightenment. Feminists have argued that over the last few centuries all scholarship was "…done by men and from a masculine point of view, utilising values that are shared by men – not women (Fennema, 1993, p.32).

Poststructural feminist research in science epistemology exposed how Enlightenment gave rise to dualism responsible for prioritising 'things' male over female, for example, male/female; culture/nature; objectivity/subjectivity; reason/emotion; mind/body and masculine/feminine. This dualist thinking "…pervades conventional epistemologies and limits what we know" (Keller, 1985, cited in Brickhouse, 1998, p.1074). From this lead, researchers turned to deconstructing the grand narrative of mathematical hegemony,

examining its exclusive Eurocentric role in determining and validating mathematical knowledge, and its colonization of mathematics by excluding other histories or cultures of mathematics (Burton, 1995). There is a need for the restructuring of theoretical and analytical approaches to the epistemology of mathematics in order to validate subjugated knowledges (Walshaw, 2001).

Feminists, using critical theory, have challenged traditional mathematics epistemology and pedagogy holding values such as subjective knowing (knowing why instead of knowing that), unity of cognitive and affective domains of thought and intuition as alternatives to objectivity, linearity and abstract rational thought. They see a need for mathematical receptivity to be replaced by mathematical enquiry, so that acquisition of knowledge is intrinsic rather than extrinsic; separate knowing to be replaced by connected knowing, knowledge to be accessible rather than exclusive, and for the teacher to become a facilitator, rather than a depositor, of knowledge (Becker, 1995; Burton, 1995; Damarin, 1995, cited in Walshaw, 2001).

Constructivist mathematics

> Although the notion of mathematics as an open, increasing system seems to be accepted in theory, in practice maths itself is not a subject which is open to debate (Witte, 1995, p.137).

Witte is referring to an alternative mathematics programme in the Netherlands called ‘user-mathematics’ as opposed to traditional ‘expert-mathematics’. In this programme, learning starts with the learner’s experiences and mathematical problems are solved in a variety of ways, with no one correct solution or solution processes. Witte’s concern is with the prescriptive nature of curriculum and textbooks, which restricts teachers from following alternative approaches. This problem is relevant to New Zealand in that constructivist approaches recommended by the mathematics curriculum are seen to be more time consuming. Texts and assessment deadlines function to restrict teacher autonomy. In addition to these constraints teachers can be tentative regarding change in

their pedagogy to that promoted by *MiNZC* because they risk losing control of their classes (Walshaw, 1996), they are unsure of the subject area (Walls, 1997), and students' may reject a change in teaching styles (Walshaw, 1996).

For those teachers who have taken up the challenge to create learning programmes that are learner centred, constructivist and gender inclusive, the outcomes are rewarding both for their own professional growth and that of their students (Becker, 1995; Burton, 1995; Witte, 1995; Walshaw, 1996). Discussing case studies involving thirteen secondary school mathematics teachers' responses to curriculum changes in pedagogical practice Walshaw observes:

> All of these teachers are committed in their own ways to the values of *Mathematics in the New Zealand Curriculum.* This commitment leads them to challenge the traditional discourse of school mathematics which has held transmission views of teaching and absorptionist views of learning. They work with diligence to try and change their classrooms from the conventional image to one that is a centre of inquiry, to a place where they might engage in in-depth exploration of mathematical ideas with their students. In their commitment some of these teachers are active not only in encouraging other teachers, but also work to connect the curriculum to the wider community (Walshaw 1996, p.37).

Professional development currently being offered to primary school teachers, through the Numeracy Project, is following a constructivist approach. This focuses on 'how the learner solves problems', and mathematical thinking strategies. Professional development is conducted school wide, and hopefully this will create new approaches and confidence for teachers (Ministry of Education, 2002). Its starting point is with the learner and that has the potential to benefit, in particular, girls and other marginalised students.

Conclusion

It is reassuring to know that by fusing theoretical approaches with constructivism, to some degree women's constructions of mathematical knowledge and approaches to

pedagogy have been accepted and prescribed in *MiNZC*. Many teachers are taking up the challenge to reflect wider perspectives in their practice. Progress is being made along the continuum from the girl being totally assimilated into the male preserve of mathematics to the changing of epistemology and pedagogy to include girls' diverse experiences and ways of knowing so that these become central to mathematics.

However, tensions abound. The underpinnings of official documents, as 'set in print', are of concern. The mathematics curriculum's rhetoric demonstrates that gender issues still prevail. According to this, girls need assistance to reach the competency of boys. This is despite evidence that girls are achieving in mathematics at the same rate, if not better, than boys. The time has come to publicly celebrate the achievements and intelligence of girls, and to value and affirm their ways of knowing mathematics.

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