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Ability grouping for mathematically gifted adolescent boys

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Embedded in the contemporary issue of gifted education is the contentious notion of ability grouping. The debate surrounding appropriate educational provision for gifted students continues to argue the cognitive and affective influences of ability grouping on gifted students. While recognising the various forms of intellectual giftedness, analysis of the research about mathematically gifted students, especially during adolescence is scarce and underrepresented (Diezmann and Watters, 2002). Adolescent boys' education coupled with a priority for mathematical giftedness is paramount in a time of technological development and advancing global partnerships for future sustainability. Recent Australian Senate Inquiries into Gifted Education (Collins, 2001), Declining Rates of Achievement and Perspectives of Adolescent Boys (Trent, 2001), and Boys' Education (Australian House of Representatives, 2002) highlight the interconnected relevance of examining mathematically gifted adolescent boys' education.

Mathematics, cognitive, affective, ability grouping, gifted

INTRODUCTION

The concept of gifted education and ability grouping continues to have a forum in many aspects of educational programming. The notion of ability grouping is broad and many variations of ability grouping are internationally recognised (Kulik, 1992; Kulik and Kulik, 1982, 1991, 1992; Rogers, 1991, 1993). International support for ability grouping is perceived in varying degrees, resulting in support from some schools while other schools communicate an anti-grouping decision, advocating for mixed ability classes (Boaler, 1997; Oakes, 1985; Slavin, 1990). It is important to realise that Oakes (1985) focused on tracking, a more rigid form of ability grouping, and Slavin's (1990) best-evidence synthesis of effect sizes from twenty-nine studies pertaining to ability grouping should be analysed with caution. Data from Savin's study reveals a neglect to discuss the positive effect sizes in thirteen of the twenty-nine studies for high achieving students in ability grouping, and seven studies have a zero effect size indicating no detrimental effect on students' achievement through ability grouping. Strong advocates for ability grouping, Kulik (1992) and Rogers (1991), found strong positive effect sizes to support all forms of ability grouping for gifted students. Many myths about ability grouping prevail in educational systems despite research evidence to support grouping practices for gifted students (Fiedler and Lange, 1994; Fiedler, Lange and Winebrenner, 1993; Rogers, 1991). Gross (2001) further extrapolates that "much of the criticism is polemic, rather than evaluative and arises from socio-political, rather than educational concerns" (p.17).

Equally prevalent is the desire to understand gifted students' perceptions of self as issues of self-concept, self-esteem, and self-efficacy may be simultaneously transferred to aspects of education. Concepts of self have an underlying importance in education as "schools are beginning to assume responsibility for teaching children that they are worthwhile, often employing standardised self-esteem tests and classroom curriculum aimed at enhancing feelings of self-worth" (Pope, McHale, and Craighead, 1988, p.1). Intellectually gifted students have many unique cognitive and affective characteristics which separate them from peers of the same chronological age such that gifted students should be placed with peers of the same mental age for at least part of their schooling day (Allan, 1991; Feldhusen, 1991; Gentry and Kettle, 1998; Gross, 1994; Hoekman, 1994; Kulik, 1992; Kulik and Kulik, 1982, 1991, 1992; Rogers, 1991, 1993; Silverman, 1993; VanTassel-Baska, 1992; Winebrenner and Devlin, 1992). Colangelo (2002) argues that "meeting the cognitive needs of gifted students often meets simultaneously their social-emotional needs" (p.5). Publications about students' achievement in gifted mathematics programs are predominantly representative of primary and secondary students who have attended a University coordinated extension course, and reveal that boys have higher mathematics results compared to girls of the same age (Benbow and Lubinski, 1991; Benbow and Minor, 1990). Research is scant on the effectiveness of gifted mathematics programs being offered in secondary schools (Diezmann and Watters, 2002). In Australia, "apathy seems a very apt word to describe the deafening silence about mathematics" (Thomas, 2000, p.4). It is clear that boys' education, specifically within the context of gifted mathematics education, have been significantly underrepresented in contemporary research agendas.

In an occasional paper of the Federation of Australia Science and Technological Society (FASTS), Thomas (2000) highlights the importance of mathematics education by stating, "within Australia, the failure to develop appropriate mathematical skills for a technological society for all young people has been given much lesser priority, both by current and previous governments" (p.3). Thomas continues to state "if Australian national sciences are to have a future than talented young mathematicians must have opportunities to develop those talents" (p.21). Diezmann and Watters (2002) elaborate on the lack of Australian contributions to research by stating that there is "a paucity of Australasian research on mathematically gifted students" (p.222). Goodrum, Hackling, and Rennie (2001) supports the necessity for Australia to raise the importance of the mathematical sciences.

Although many studies have focused on the influence of full-time ability grouping on self-concept and self-esteem for students in primary schools, there are few published studies examining the effects of ability grouping for students in secondary schools (Craven and Marsh, 2000; Janos, Fung, and Robinson, 1985; Janos and Robinson, 1985; Marsh, Chessor, Craven, and Roche, 1995). Research suggests that global self-concept and self-esteem of gifted students is high compared to students of average ability, yet there is some disagreement about ability grouping and its affect on the subcomponents of self-concept and self-esteem (Gross, 1997; Hoge and Renzulli, 1993; Janos, Fung, and Robinson, 1985; Janos and Robinson, 1985; Kulik, 1992; Marsh, et al., 1995; Marsh and Craven, 1994; Rogers, 1991). Gross (1997) found that while gifted students' self-esteem declined upon enrolment, in a selective high school, levels of self-esteem became more realistic as gifted students may have previously held elevated perceptions of their capabilities in a mixed ability environment.

Self-efficacy refers to a person's perception about their ability to achieve goals or complete challenging tasks (Bandura, 1986, 1997; Schunk, 1996). Self-efficacy is a component originating from Bandura's (1986, 1997) social cognitive theory which states that self-efficacy results from the interactions between performance, vicarious experiences, verbal persuasion and physiological state (Starko and Schack, 1989). Mathematical self-efficacy is related to students' perceptions of their ability to complete specific mathematical tasks. Gifted boys have been found to have higher mathematical self-efficacy compared to both females and average ability mathematics students (Benbow and Lubinski, 1991; Benbow and Minor, 1990; Hoge and Renzulli, 1993; Janos and

Robinson, 1985; Junge and Dretzke, 1995; Pajares, 1996a, 1996b, 2002; Pajares and Graham, 1999; Pajares and Kranzler, 1995; Ross and Parker, 1980).

Few studies have been completed about mathematical ability grouping, gifted mathematics programs being implemented in ability grouping environments, and mathematical self-efficacy in the secondary school. The research about specific regrouping of gifted adolescent mathematicians for instruction is scant, and there is minimal explanations of how and why regrouping gifted students for mathematics influences the three aspects of self-concept, self-esteem, and self-efficacy. It has been suggested that ability grouping for a specific curriculum area produces substantial academic gains in achievement, improves general attitude towards schooling and enhances self-efficacy in specific domains (Rogers, 2001a, 2001b; Kulik, 1992; Kulik and Kulik, 1991, 1992). Rogers' (2001a) meta-analyses of ability grouping and acceleration reveals that regrouping for mathematics instruction yields an effect size of 0.76, providing the curriculum is differentiated (Allan, 1991). If only the pace of instruction is altered and no differentiation occurs, the effect size reduces to 0.57.

Inherent in catering for mathematical giftedness is a curriculum creating opportunities to optimise students' potential (VanTassel-Baska, 1993). A goal in gifted education is to reach the 'optimal match' of curriculum with the needs of gifted students (Hoekman, McCormick, and Gross, 1999). It is argued that curriculum should be complex, fast-paced, rigorous and match the abilities and interests of gifted students (Gross, 1994, 1997, 2001; Rogers, 2001b; Sawyer, 1988; VanTassel-Baska, 1988, 1991, 1992, 1993, 1998). Matching curriculum to the needs of gifted students can be achieved through a range of curricular practices such as above level testing, curriculum compaction (Reis, Westberg, Kulikowich, and Purcell, 1998) and curriculum differentiation (Gross, Sleap, and Pretorius, 2001). Students should be able to compact the curriculum by completing a variety of pre-and above level tests (Starko, 1986).

The purpose of these tests is to ascertain knowledge and skills already mastered so that gifted students can complete work at greater depth and complexity or accelerate their learning. Mathematical giftedness can be defined by specific cognitive and affective characteristics. Gifted mathematicians exhibit many of the specific characteristics outlined in Table 1.

Table 1. Characteristics of Mathematical Giftedness

Formalised perception of mathematics
Solve complex problems (usually at a young age)
Logical thought about quantitative and spatial relationships
Think in mathematical symbols and flexibility of thought
Rapid and broad generalisations of relations and operations
Curtailment of mathematical reasoning
Rapid reconstruction of mental processes and reversibility of mathematical reasoning
Mathematical memory for relationships, arguments, proofs, principles of problems solving
Energy, persistence and concentration
Organise data to consider patterns or relationships
Analyses problems, considers alternatives
Learns mathematical concepts and processes faster than other students
Able to verbalise mathematical concepts, processes and solutions
May enjoy difficult problems, puzzles and logic problems
Develops unique associations, uses original methods for solutions
Sometimes solves problems intuitively, and may not be able to explain why the solution is correct

Adapted from: Feldhusen, Hoover, and Sayler, 1991; House, 1987; NCTM, 2000; Wieczerkowski and Prado, 1993

High school males have higher academic mathematical achievement results on standardised and class tests, and enhanced mathematical self-efficacy, compared to high school females (Junge and Dretzke, 1995; Lubinski, Benbow, and Sanders, 1993; Sowell, 1993; Terwilliger and Titus, 1995). Reviews of mathematics programs and characteristics of mathematically gifted students reveal that high spatial ability, independence, motivation and flexibility of thought are indicative of very high mathematical achievement (Benbow and Lubinski, 1991; Benbow and Minor, 1990; Olszewski-Kubiliyus, Kulieke, Shaw, Wilhus, and Krasney, 1990; Stanley, 1993). Recognising that "curriculum is the medium through which learning occurs" (NCTM, 2000, p.31), gifted students should have opportunities to develop abstract thinking skills and engage in higher cognitive processing.

PROPOSED CASE STUDY

An explanatory case study is currently being conducted to investigate how regrouping gifted Year 8 students for mathematics influences aspects of self. The focus of the case study are five students from Year 8 Extension Mathematics (n=43), receiving a differentiated mathematics curriculum compared to students in the remaining six mixed ability mathematics classes (n=123), specifically analysing the affects of ability grouping on aspects of adolescent boys' self-concept, self-esteem, and mathematical self-efficacy. The students in the Extension Mathematics classes are representative of mildly, moderately and highly gifted students. Extension Mathematics is an example of regrouping for specific instruction (Rogers, 1991; Kulik, 1992).

The case study is theory-testing and will investigate the influence of ability grouping on mathematically gifted adolescents' aspects of self. It is envisaged that this research will inform practice in gifted education, mathematics education, and has relevance for aspects of psychology. The research makes the assumption that ability grouping for mathematically gifted adolescent boys will at least have a neutral effect on self-concept, self-esteem, and mathematical self-efficacy. Results from three standardised measures, Self-Esteem Inventory (Cooper-Smith, 1969/1989), Self Description Questionnaire II (Marsh, 1990), and Mathematical Self-Efficacy Scale (Betz and Hackett, 1983), will be analysed at pre- and post-test stages to understand the influence of regrouping for mathematics. Semi-structured interviews will also be used to gain further understanding about students' and teachers' perceptions of how and why ability grouping influences aspects of self. Students in the Extension Mathematics class will also complete a problem solving activity aimed at investigating aspects of mathematical self-efficacy.

The Extension Mathematics program is a gifted program that has implemented many recommendations from the research literature for gifted curricula. The guiding principles for the Extension Mathematics Program include: (i) rapid progression, (ii) acceleration, (iii) ability for abstraction and complexity, and (iv) solving challenging problems. Characteristics of gifted learners and gifted mathematicians which the program specifically addresses includes an ability to learn at a fast pace, dealing with complex and ambiguous concepts, intuitive perception to solve problems and use mathematical conventions, rapid and broad generalisations of relations and operations, mathematical memory for relationships, arguments, proofs, principles of problems solving, persistence and concentration, an ability to develop unique associations and use original methods for solutions (Feldhusen, Hoover, and Sayler, 1991; House, 1987; NCTM, 2000; Wieczerkowski and Prado, 1993).

Multiple selection criteria enable data to be collated about individual students. In 2003, the program structure maintains the schools' traditional structure of eight, Year 8 classes. As the mathematics classes are timetabled in two blocks, two Extension Mathematics classes were created. Other students remain in mixed ability environments. Figure 1 presents an illustration of the 2003 program structure.

RESULTS

Preliminary results for the two standardised measures for self-concept and self-esteem reveal consistencies with existing research as outlined previously. It is important to understand that the measures were administered prior to selection for the Extension Mathematics program. Subcomponents of self-concept reveal gifted students have higher means compared to other Year 8 students in six of the eleven subcomponents, and have higher global self-concept means. Means were higher in mathematics, general self, honesty-trustworthiness, verbal, emotional stability, general school, and same-sex relations. Similar results were found in parent relations, with gifted students having a mean greater by 0.22. Slightly lower means for gifted students were found in physical appearance, physical ability, and opposite-sex relations.

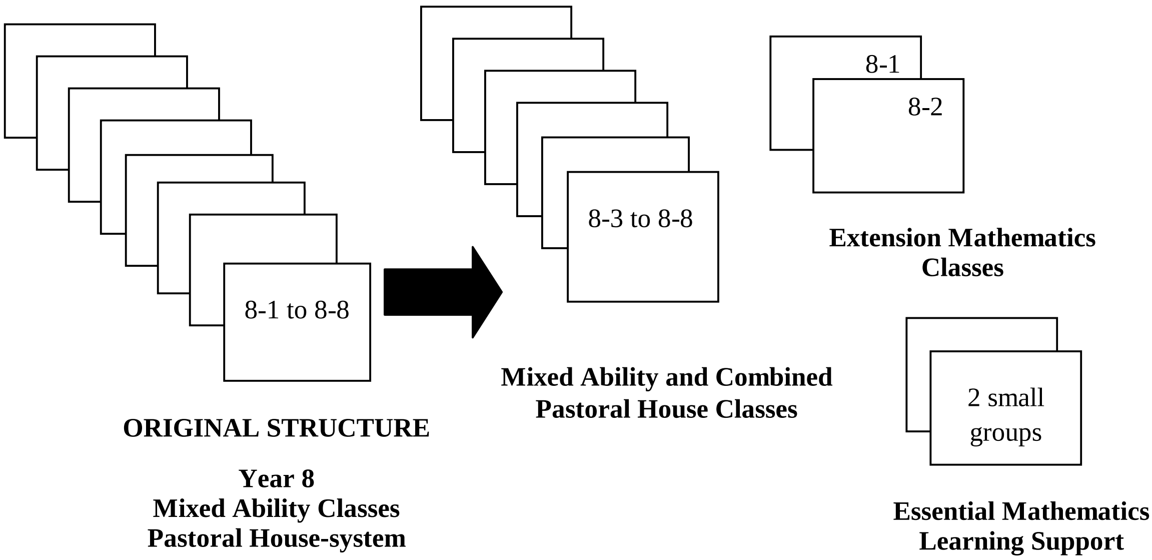

Figure 1. Structure for the Year 8 Mathematics classes

Analysis of self-esteem also reveals higher global and school/academic self-esteem, and home/parent relations. A higher mean difference of 0.26 was found for general self-esteem. Social self-esteem was lower compared to other Year 8 students with a mean difference of 0.23. Table 2 outlines means for the two measures. Comparison with the norms for self-concept and self-esteem reveals that both groups of students have higher means for all subcomponents of self.

FUTURE DIRECTIONS

Research about ability grouping and its influence on aspects of self is divided. Although some researchers strongly urge for ability grouping, other results indicate that ability grouping causes a decline in global self-concept and self-esteem. It seems that one of the agreements is that gifted students' global self-esteem remains higher compared to students of average ability. Research has revealed implications of ability grouping and usually in the context of full-time ability grouping and usually publishes results in the global scale and does not always indicate results from subcomponents of self-concept and self-esteem.

Generalising these results across all forms of ability grouping and in the secondary school should be cautioned. Research about students completing a differentiated program in the secondary school setting and its influence on aspects of self is scant. The current study is relevant as it addresses the gap in knowledge to ascertain how regrouping mathematics instruction influences aspects of self for gifted adolescent boys. Analysis of the data yet to be collected from the semi-structured interviews, problem solving self-efficacy activity, and post-test standardised measures will reveal how and why regrouping influences aspects of mathematically gifted adolescent boys' self-concept, self-esteem, and self-efficacy. In a time of rival propositions concerning boys' education and gifted education, the influence of regrouping gifted adolescent boys for mathematics instruction is paramount. A new millennium of research should continue to inform professionals of effective pedagogy and productive partnerships that place students and the learning process as the central force which progressively drives contemporary and further educational systems. It is timely that rival theories be considered and that if necessary new theories be postulated about the education of mathematically gifted adolescent boys.

Table 2. Comparison of norms for self-concept and self-esteem

Subcomponent	Gifted Students	Other Year 8 Students	Normed Means (Year 9)
Self-Concept			
Mathematics	51.12	42.78	37.5
Physical Appearance	35.74	36.51	34.2
General Self	52.28	49.81	49.1
Honesty-Trustworthiness	49.53	46.98	41.8
Physical Abilities	38.88	39.63	38.0
Verbal	47.23	43.10	39.2
Emotional Stability	45.14	44.59	41.5
Parent Relations	42.65	42.43	39.1
General School	52.02	46.70	43.3
Same-Sex Relations	53.37	51.66	46.0
Opposite-Sex Relations	37.12	38.72	35.2
Global Self-Concept	501.84	482.53	444.8
Self-Esteem			
General	41.81	41.15	33.2
Social	13.3	13.07	10.9
Home/Family	13.4	12.96	9.1
School/Academic	12.7	11.87	7.9
Global Self-Esteem	81.21	79.06	61.2

Source: Coopersmith (1989); Marsh (1990)

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