

Effect of streaming by gender on student achievement in mathematics in secondary schools in Kenya

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We present findings of a study carried out to determine the effect of streaming by gender on secondary school students' achievement in mathematics. In the study we analysed achievement scores on national examinations results for the years 1999 to 2001 of a sample of 1 489 candidates in four secondary schools in Nakuru District, Kenya. Raw data were analysed statistically and the hypotheses tested. Generally, the results indicated that streaming based on gender improved overall student achievement in mathematics and especially that of girls. Although further studies are needed to incorporate this result into official policy, there are strong indications that streaming by gender may be a useful class environment as an intervention towards improving the performance of girls in mathematics in co-educational schools.

Keywords: achievement; class environment; examinations; gender; Streaming

Introduction

In earlier days, and especially in traditional African systems, informal education tended to separate girls from boys as the knowledge, skills and values given were extremely sex stereotyped. This trend continued even when education became more formalized, structured and comprehensive. Education of the boy child was given greater importance than that of girls. Although there was a gradual extension of education to the girl child, girls were taught separately from boys, resulting in a predominance of single-sex schools. The co-opting of girls into boys schools (Knight, 1999) was adopted over time due to civil pressure and advocacy for the recognition of equal rights of the girl child in education.

Although co-education became a normal system in education structures, it aroused intense interest among not only educators but also the public at large. The subject has been discussed from diverse points of view, particularly moral, economic, social, and educational. There have been significant divergences of opinion as to the wisdom of co-education particularly in secondary schools, with some people arguing for it and others against it. Most times, the rationale for these debates has been on matters of managing student discipline rather than directly being related to achievement issues. In this study we attempted to analyse the effect of streaming by gender on student achievement in mathematics, with particular focus on the girl child. This case was justified on what has been given in theoretical literature and research findings concerning the different learning styles between girls and boys and the likely effect of these on cognition and examination achievement, particularly in mathematics (Mondoh, 2000; Changeiywo, 2000).

Review of literature

The specific interest on the variance of gender differences in mathematics teaching, learning and achievement is explained on the basis of gender differences on cognition and brain lateralization (Fennema & Leder, 1990; Mondoh, 2001). These differences have implications on instructional procedures to be adopted for purposes of setting up an appropriate teaching / learning environment for mathematics instruction that is suitable to both genders.

Mondoh (2001) argues that people differ in learning according to how they perceive and process reality. The key argument describes a combination of perceiving and processing techniques that result in the formation of four unique learning styles, referred to as the four-mat system (Barmao, 2006). This system is largely associated with gender, and produces four types of learners. Each of these types of learner is characterized by certain attributes that are either compatible or non-compatible with the requisite expectations for learning and understanding mathematics.

Type one learners perceive information concretely and process it reflectively. They learn best by personal involvement, listening and sharing ideas. Their favourite question is "Why". Teachers therefore need to provide them with reasons for learning a particular concept. It is recommended that this type of learner be taught using group work approach (Mondoh, 2001). Girls are more likely to be in this category of learners. This implies that in situations where mathematics lessons are teacher-dominated and individualized, girls are likely to lag behind boys.

Type two learners are observers and thinkers who are best taught using experimental methods, which are practical and require use of mathematics laboratories and instructional aids (FAWE, 1997; Mondoh, 2001). The majority of girls are inclined to learning through this approach (Mondoh, 2001), so that in cases where such instructional environment is unavailable, they are likely to be disadvantaged (Nwosu & Omeje, 2008).

Type three learners perceive information abstractly and process it actively. They like trying things out for themselves. Mondoh (2001) says their favourite question is "How". Such learners prefer real and relevant "hands on" activities that relate to real life, especially those within the context of their own lives and environment (FAWE, 1997). According to Mondoh (2001), this category of learner can apply concepts to new situations and cope with lots of homework individually. Boys are recognized to have these attributes, which are also favourable for learning mathematics.

Type four learners are risk takers and dynamic. Their favourite question is "If". It is recommended that such type of learners are inclined to work on their own or left on their own to teach themselves and others. Self-discovery is the best method for teaching them. This is also another very good attribute in learning mathematics and is more prevalent in boys than in girls.

In addition, peoples' ways of thinking and learning have been identified in ten categories (Mondoh, 2001; Barmao, 2006). These are: reflective versus impulsive, serialist versus holistic, field-independent versus field-dependent,

convergence versus divergence and confidence versus caution cognitive styles. Generally, these cognitive styles affect different learners differently. Similarly, both the teacher and the learner, just like the females and males, have their own unique cognitive styles. Hence, compatibility or incompatibility between their preferred thinking is likely to affect understanding and performance in mathematics.

For example, boys are impulsive, holistic in approach, field independent, have convergent attributes and are confident. On the other hand, girls are reflective, serialist, field dependent, divergent in thinking and cautious in the process of dealing with matters (Mondoh, 2001; Costello, 1991). These different cognitive attributes affect boys and girls differently, especially with regard to confidence levels, attitudes, ability to take risks, interaction and intellectual dexterity. Some of the attributes favour boys more, compared to girls with respect to learning and understanding mathematics (FAWE, 1998; Changeiwo, 2000).

Brain lateralization has also been used to explain the cognitive differences that lead to differences which are in favour of boys' higher achievement in mathematics (Bryden, 1979). The explanation given has been that the right hemisphere, which controls spatial related activities, develops earlier in boys compared to girls. Spatial skills or spatial visualization is the ability to visualise movement of geometric figures in one's mind. Hence, a person with greater competence in spatial related activities is likely to perform well in science and mathematics. This explains why, given a similar age cohort of students, boys are more likely to be good in science and mathematics compared to girls.

Research findings are inconsistent on the effects of single-sex schools on students' performance in mathematics. Some studies (Colley, Comber & Hargreaves, 1994; Mallam, 1993) have found gaps favouring girls in single sex schools, but once these findings were adjusted for socio-economic or ability variables, the differences diminished. For example, Harker and Nash (1997) in a longitudinal study of more than 5 000 eighth-grade students in New Zealand controlled for individual characteristics such as socioeconomic status and school type. The study confirmed statistically significant differences in student performance in favour of girls in single-sex schools. However, after applying controls for ability levels and for social and ethnic backgrounds, the differences disappeared.

Lepore and Warren (1997) conducted a study in America and found that boys in single-sex schools did not increase their test scores more than boys in co-educational schools did. Similarly, girls experienced no significant positive effects of single-sex school environment. In contrast, Githua (2002) in a study on the factors related to the motivation to learn mathematics among school students in Kenya found that boys in boys' only schools were more motivated during mathematics teaching and learning and were likely to be superior in performance compared to boys in other types of schools. However, the study did not control for ability level of the students.

Studies that have found positive achievement outcomes attributable to the single-sex environment have all dealt with single-sex schools rather than classes. The study by Lee and Lockheed (1990) in ninth-grade Nigerian public schools measured mathematics performance and stereotypic views of mathematics. They found no significant gender gap between mathematics scores of Nigerian boys and girls once other variables were taken into account. They also found that girls in single-sex schools outperformed other girls in mathematics, while boys in single-sex schools did the reverse. The study was then adjusted for student background, school resources and teacher attitudes. It was found that girls in single-sex schools had a less stereotypical view of mathematics, while boys in single-sex schools had magnified stereotypes of the subject.

From the above studies, there is some inconsistency of findings on whether single-sex education brings about improved student achievement in mathematics. Some studies (such as Riordan, 1990) recognized that some single-sex schools were "doing something different" that might be reproduced in the co-educational context. Riordan (1990) views policy and training interventions as being valuable. Although studies find that girls view the single-sex schools as more conducive to their learning, past research fails to confirm significant gains in girls' performance in mathematics in such school environments.

Most girls underestimate their own academic ability and believe boys to be relatively more superior and intelligent in handling difficult subjects like mathematics (Mondoh, 2001). This is more of a stereotypical perception, which makes boys feel superior to girls in studying what is regarded as tough subjects (Githua, 2002). Such a situation presupposes that the mixed-sex school environment is likely to inhibit the performance of girls in mathematics.

Background to the study

Because of its perceived role in scientific and technological development, mathematics is a compulsory subject in the secondary school curriculum in Kenya (Republic of Kenya, 1999). In addition, the concepts and principles of mathematics are regarded as useful and are applied in the study of other subjects such as Economics, Engineering, Biological Sciences, Medicine, Geography, and Management Sciences (FAWE, 1998). However, in spite of all these, students' performance in mathematics examinations has been poor, with less than 15% of the students who enrolled for mathematics obtaining grade D+ (30–40%) and above for most of the years since 1994 (Kenya National Examinations Council, 1999). Girls are relatively worse off in this performance as compared to boys. This situation is likely to compromise Kenya's efforts in achieving its goals of scientific and technological development.

In an attempt to improve the performance of girls in mathematics, many studies have been done and various recommendations made. These include

teaching girls through use of the Integrated Programmed Instruction (IPI) method, gender-sensitive instructional methods and learning materials; use of gender-sensitized modes of assessment; female teacher role models in mathematics classrooms; co-operative mode of teaching and the use of sex-neutral media in the teaching of mathematics.

Of even greater concern is that girls in particular continue to perform poorly compared to boys. This problem seems to be most prevalent in co-educational schools. The main argument is that such classroom instructional environments favour boys at the expense of girls. Recently, there have been suggestions of separating boys and girls in instructional environments, on the grounds that the learning of mathematics by girls may be inhibited by the presence of boys (Pamela, 2000; Githua, 2002). Consequently, in the recent past, some co-educational schools have separated boys from girls to teach them in separate classes. However, the implications of this action on student's performance in the subject have not been explored. Further, some scholars have argued that such separation may lead to declining performance of boys in mathematics since it is in the presence of girls that boys stand out (Lepore & Warren, 1997).

However, the results of this kind of intervention are not clear. In addition, research findings on the effect of class separation on the basis of sex on student achievements have been inconsistent. In the absence of empirically derived and verifiable justification, it has been difficult to adopt this model as a significant intervention that would improve the overall performance of girls in mathematics. Therefore, in this study we sought to find out the effect of streaming by gender on students' achievement in mathematics, with particular focus on girls. The specific objectives were to:

- Determine whether there is a difference in performance in mathematics among students in mixed segregated, mixed normal, and single-sex schools (boys' only and girls' only).
- Determine whether there is a significant improvement in performance in mathematics when students are segregated by gender.

These objectives were achieved through the following hypotheses:

H₀₁: There is no statistically significant difference in performance in mathematics among students in mixed sex-segregated; mixed sex-normal, and single-sex schools (boys' only and girls' only).

H₀₂: There is no statistically significant improvement in performance in mathematics when students are segregated by gender.

Research plan and design

In this study we used an ex post facto research design to guide the collection and analysis of data. The study focused on public schools that were categorized based on school type and class arrangement. These were:

- mixed sex-segregated, (Nakuru High School), where students were in separate classes based on sex;

- normal mixed sex (Kabarak High School), where both the boys and girls were taught in the same classes, and
- single-sex schools (boys only, Utumishi Academy, and girls only, Moi Forces Academy).

These schools were selected for the study because they were in the national category of schools classification in Kenya. In this respect, they were similar in terms of school facilities for instruction. They also normally admitted the best qualified students from a nationwide catchment

These schools provided an accessible population of 1 489 students, which also constituted the sample for the study. These groups of students were selected according to the research plan. In 2000 and 2001, students in the mixed sex-segregated school sat their national examinations after having been taught in single-sex classes for two years preceding the final examinations. On the other hand, the earlier class of 1999 had been taught in normal mixed classes.

Data collection and procedure

Data were collected using documentary search and analysis of examination results of a sample of 1 489 Form 4 mathematics examination candidates for the years 1999, 2000, and 2001, from the four schools. The 1999 results were for the mixed sex-segregated school only. The sample was distributed based on gender and school type as shown in Table 1.

Table 1 Distribution of sample by gender and school type (N = 1 489)

School type	Boys	Girls	Total
Girls only	–	174	174
Boys only	242	–	242
Mixed sex normal	242	78	320
Mixed sex segregated	568	185	753
Total	1 052	437	1 489

Data in Table 1 show that out of the total sample of 1489 candidates, girls constituted approximately 29% while boys made up 71%. This trend reflects the overall enrolment patterns in secondary schools in Kenya.

The study generated quantitative data that were analysed using the mean and standard deviation. Hypotheses were tested using the *t* test and one-way analysis of variance ($\alpha = 0.05$).

Data presentation and discussion

The results of this study focused mainly on making comparisons on the effects of segregation on student achievement in mathematics examinations. The comparisons were made between the student cohort of 1999, who were

taught in a normal mixed classroom environment, and the cohorts of 2000 and 2001, who were separated and taught in single-sex environments prior to sitting for their examinations. Achievement scores for the single-sex streamed schools were included for analysis in an attempt to make the comparisons more comprehensive.

Comparison of students' performance in mathematics in mixed sex-segregated, normal mixed sex, and single-sex schools

Results of students' performance in national mathematics examinations for the years 2000 and 2001 were obtained and analysed based on the four school types, namely, mixed sex-segregated, normal mixed sex, boys' only and girls' only schools. The hypothesis tested was:

H0: There is no significant difference in performance in mathematics among students in mixed sex-segregated, mixed normal, and single-sex (boys' and girls' only) schools.

The data were analysed by computing the mean scores by school type and gender (Table 2), and the hypothesis tested using one-way Analysis of Variance ($\alpha = 0.05$).

Table 2 Mean scores and ANOVA of student achievement in mathematics examinations (2000 and 2001) by school type (N = 1 231)

	N	Mean score	SD	F ratio	Tukey's HSD
Girls only	174	5.8793	2.8955	41.525*	$p < 0.05$
Boys only	242	6.6570	3.4512		
Mixed sex-segregated	495	6.5475	3.3192		
Mixed sex normal	320	8.6781	2.8184		

* Significant ($p < 0.05$)

The results in Table 2 show that in 2000 and 2001, students in the normal mixed school scored higher achievement scores relative to the other schools. Students in the girls' only school scored the lowest mean. Results from the one-way ANOVA revealed an overall statistically significant F ratio at $p < 0.05$. Tukey's honestly significant difference (HSD) test shows that the mean differences in mathematics achievement between the four groups of students were significant at $p < 0.05$. Students in the normal mixed school achieved significantly higher mean scores compared to all the other schools.

Comparison of the performance of girls in mathematics examinations by school type

The scores achieved by girls in national mathematics examinations for the years 2000 and 2001 in the three types of schools, namely; mixed sex normal, mixed sex-segregated and girls' only were analysed to determine whether

there were significant differences in the means. The results of the statistical analysis are given in Table 3. The analysis was based on the following hypothesis.

H0: There is no significant difference in girls' performance in mathematics by school type.

Table 3 Mean scores and ANOVA for girls' achievement in mathematics examinations (2000 and 2001) by school type (N = 359)

	N	Mean score	SD	F ratio	Tukey's HSD
Girls only	174	5.8793	2.8955	11.635*	p < 0.05
Mixed sex-segregated	107	5.9346	3.1571		
Mixed sex normal	78	7.7308	2.8498		

* Significant ($p < 0.05$)

Results in Table 3 show that the mean score for girls in the normal mixed-sex school was relatively higher compared to the other types of schools. Results from the one-way ANOVA revealed an overall statistically significant F ratio at $p < 0.05$. Tukey's honestly significant differences test showed that the mean differences in mathematics achievement between these groups of schools were significant at $p < 0.05$. Girls in the normal mixed-sex school scored significantly higher than those in girls' only and mixed sex-segregated schools. These results imply that girls taught in mixed-class environments scored relatively higher compared to those taught in single-sex class environments. This finding is consistent with studies and observations made by Lepore & Warren, (1997) and Knupfer, Rust and Mahoneyl (1997) that the performance of girls did not change when taught in single-sex environments compared to when taught under mixed-class conditions. Knupfer *et al.* (1997) concluded that mixed-class environments tend to encourage girls to study and pass in mathematics and that they are very important in helping both boys and girls to learn to work together as they model the behaviour they will need as adults.

Comparison of the performance of boys in mathematics examinations by school type

We further analysed and compared (Table 4) the performance of boys in mathematics examinations results for the years 2000 and 2001 in normal mixed-sex, mixed sex-segregated and boys' only schools. The research hypothesis generated was:

H0: There is no significant difference in boys' performance in mathematics by school type.

Table 4 Mean scores and ANOVA for boys' results in mathematics examinations (2000 and 2001) by school type (N = 872)

	N	Mean score	SD	F ratio	Tukey's HSD
Boys only	242	6.6570	3.4512	44.179*	$p < 0.05$
Mixed sex-segregated	388	6.7165	3.3468		
Mixed sex normal	242	8.9835	2.7450		

* Significant ($p < 0.05$)

The results in Table 4 indicate that the mean scores obtained by boys in the normal mixed-sex school were higher than in the two other types of schools. Achievement scores were relatively higher for mixed sex-segregated schools compared to the boys' only school. This suggests that boys in the normal mixed-sex school outperformed the other boys in the other types of schools in mathematics. The result from the one-way Analysis of Variance shows an overall significant F ratio at $p < 0.05$. Results for Tukey's honestly significant differences test show that the mean differences in scores in mathematics achievement between the boys in the three types of schools were significant at $p < 0.05$. The boys in the normal mixed-sex school scored significantly higher than those in the boys' only and mixed sex-segregated schools.

These findings agree with those of Lepore & Warren, (1997) who found that boys in mixed normal classes performed relatively better than boys in boys' only classes. Specifically, the focus of argument was that in co-educational schools, the presence of girls is necessary in order to promote the positive image of boys, and that since mathematics is considered masculine, boys especially in normal mixed classes will perform better to prove their masculinity (Mondoh, 2001).

Effect of segregation by gender on students' performance in mathematics

The effect of segregation by gender on students' performance in mathematics was analysed using mathematics examinations results for the years 1999, 2000, and 2001 in the mixed sex-segregated school. Students scores obtained in 1999 were compared with those obtained in 2000 and 2001. This was because in 1999, students sat for their national examinations when boys and girls were taught in the same class. The 2000 and 2001 students' cohort sat for their national examinations after having been taught in sex-segregated classes. The research hypothesis was:

H0: There is no significant improvement in performance in mathematics when students are segregated by gender.

The results of the analysis showed that the mean scores in mathematics examination for the students in the mixed sex-segregated school in mathematics were higher when the students were taught in separate classes.

Generally, the overall results improved from an average of 5.4 in 1999 to 6.6 points in 2001, and the differences in student performance for the two cohorts of students were significant (t , 1999/2000 = 3.80, $p < 0.05$; and t , 1999/2001 = 4.14, $p < 0.05$).

Table 5 Mean scores and standard deviations in mathematics examination results in the mixed segregated school by sex

Year	Boys (N = 568)			Girls (N = 185)		
	N	Mean score	SD	N	Mean score	SD
1999	180	6.1222	3.2316	78	3.7308	2.2602
2000	182	6.6044	3.2052	52	6.1154	3.3116
2001	206	6.8155	3.4718	55	5.7636	3.0244
1999/2000:	$t = -1.43; p > 0.05$			$t = 4.882; p < 0.05$		
1999/2001:	$t = 2.021; p < 0.05$			$t = 4.436; p < 0.05$		

1999/2000: $t = 3.80, p < 0.05$; 1999/2001: $t = 4.14, p < 0.05$

Results in Table 5 indicate that the mean scores of both boys and girls were higher when they were taught mathematics in separate classes (2000 and 2001) than when they were taught in the same class (1999). There was a marked improvement by girls after segregation from a mean of 3.7 in 1999 to a mean of 6.1 and 5.8 in 2000 and 2001, respectively. This implies that streaming by gender in the mixed sex-segregated school may have led to improved performance of both boys and girls in mathematics examinations.

Further, t tests were computed to determine the significance of the differences in mean scores obtained when boys and girls were considered separately. The results for girls indicated that the t values for both pairs of years (1999/2000 and 1999/2001) were statistically significant at $p < 0.05$. The girls scored higher in separate classes compared to when they were taught together with boys in the same classes. On the other hand, in the case of boys, the differences in examination scores between 1999 and 2000 were not statistically significant at $p = 0.05$. However, they were significant for 1999 compared to 2001. These results indicate that, generally, both boys and girls are likely to gain from streaming classes on the basis of gender, and specifically, girls are likely to gain most.

Conclusions

The results of this study are threefold. There is a statistically significant difference in the performance of boys and girls in all the three types of schools. Generally, the boys perform better than girls do. This means that despite the type of school that learners attend, boys are still likely to score better in mathematics examinations than girls. It may be attributable to many factors, but perhaps the cognitive learning styles may be favouring boys in understand-

ding and subsequent good performance in mathematics. Similarly, it may also be likely that without deliberately doing so, teachers' approaches to handling mathematics-learning interactions may be favouring boys against girls.

Students taught in normal mixed classes scored relatively higher compared to those in either mixed-segregated or single-sex schools. Similarly, taken separately, both girls and boys scored relatively higher in mathematics examinations when taught in normal mixed classes. On the other hand, after segregation, there is an indication that overall performance improved, but there was greater improvement on the part of girls. This implies that girls are more likely to benefit most from streaming by gender.

A number of implications can be inferred from these findings. Although streaming by gender led to improved performance of girls in the mixed sex-segregated school, this performance is lower than that of girls in the normal mixed-sex school. This suggests that there was something uniquely different in the normal mixed-sex school that needed to be exemplified in the other schools. Most likely, these differences may have been caused by such factors as student interests and attitudes, teacher commitments to accomplishing tasks, school resources and teacher experience, and support from school leadership. In addition, teachers pointed out that strict supervision of students, a high degree of discipline in the school, and abundance of teaching resources could make students concentrate more on their academic activities, hence their improved performance in mathematics.

The inconsistency of the results also indicates that separation of classes based on gender may not be a viable option to effective management of curriculum implementation at the school level, especially with regard to mathematics teaching and examinations. Since a number of schools have taken this option with the view of improving general aspects of school discipline and enhancing student performance in examinations, the area is still a rich ground for in-depth studies and investigation as a policy option.

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