RELATIONSHIPS AMONG FOUR DEMOGRAPHIC VARIABLES AND THE PERFORMANCE OF SELECTED JAMAICAN PRESERVICE PRIMARY TEACHERS ON PERIMETER, AREA AND AREA-PERIMETER

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This study was designed to find out if (a) the level of performance of selected Jamaican preservice primary teachers on perimeter, area and area-perimeter was satisfactory; (b) there were significant differences in their performance on each of the three concepts based on their gender, cohort, age and mathematical abilities; and (c) there were significant correlations among their four independent variables and their performance on each of the three concepts. The 200 student-teachers (166 females and 34 males) were chosen from three colleges. An 18-item multiple-choice test and four structured questions on perimeter, area and area-perimeter were used for data collection. The findings showed that (a) the participants' performance on the three mathematics concepts was "barely" satisfactory; there were statistically significant mathematical ability differences in their performance on each the concepts in favour of students with high mathematical abilities, while there were no significant gender, cohort and age differences in their performance; and (c) there was a positive, statistically significant but weak relationship between the students' mathematical abilities and their performance on perimeter, area, and area-perimeter.

Introduction

The teaching of mathematics at the primary level demands that prospective primary school teachers should be prepared to teach every content ranging from the basic counting of numbers to algebraic skills (Franke, 2000). But it is a widely held opinion that teachers at the primary level lack the necessary mathematical knowledge needed to effectively teach the subject (Jeffrey, Murray, Humble & Robinson, 1995). Post, Harel, Behr and Lesh (1991) as cited in Stevens and Wenner (1996) asserted that the lack of mathematical understanding at the conceptual level was thought to be of particular difficulty for elementary teachers who needed to teach fundamental concepts to young students. Again, Brown, Cooney and Jones (cited in Lubinski, Thomason & Fox, 1998), indicated that preservice elementary teachers possessed an inadequate level of the conceptual understanding necessary for teaching mathematics.

The results of the Third International Mathematics and Science Study (TIMSS, 1996) revealed that many students worldwide performed poorly in science and mathematics. Similarly, evidence from the Caribbean Examinations Council's (CXC) reports from 1998 to 2003 showed that less than 40% of the Jamaican 11th-graders, who sat the CXC's secondary education general proficiency examinations in mathematics, attained Grades I to III (CXC, 2003). Whereas other tertiary level institutions have stringent policies on the numbers of subjects candidates could be allowed to obtain Grade III on, to qualify for admission into Jamaican teachers colleges, many students are admitted even if they have Grade III in all the subjects required for entry including mathematics. Indeed, in most cases, many of them are allowed to study mathematics at the teachers' colleges even when they did not pass the subject at the general proficiency level but would be allowed to resit and pass it before the completion of the programme. In short, many of the inservice and preservice mathematics teachers in Jamaican primary and secondary schools were the products of the Jamaican primary system where the teachers mostly had very poor mathematics backgrounds (Bell-Hutchinson, 2004). Since 1998, Grades I–III are considered as passing "Grades" in each of the school subject that the CXC examines grade 11 students (15-17-year-olds) on at the end of a five-year secondary education; Grade I is regarded as a "Distinction".

Most of the teachers who teach in Jamaican primary schools are graduates of the Jamaican teachers colleges where they are prepared as general classroom teachers. However, they were introduced to strands of mathematics such as statistics, geometry, numbers, measurement and graphs. This is done throughout the 3-year duration of their training during which they are (a) introduced to the methods of teaching mathematics; (b) taught how to implement the different mathematics curricula that have periodically been introduced at the primary level; and (c) exposed to supervised teaching practice during which they are allowed to teach mathematics lessons to students in classroom situations.

Mathematics has many different strands (e.g., numbers, measurement, geometry, algebra, trigonometry and statistics). Measurement topics, including area and perimeter, are basic to the competency domain expected of primary school teachers. According to the National Council of Teachers of Mathematics (NCTM, 2000), the study of measurement is important in the mathematics curriculum from pre-kindergarten through high school because of the practicality and pervasiveness of measurement in so many aspects of everyday life.

In the Jamaican context, the precursor of perimeter is introduced as early as Grade 2 by comparing and ordering objects in terms of longer and shorter. Length is really the focus of Grades 2 and 3 with the idea of perimeter being formally introduced in the latter part of Grade 3. Area is also introduced in the latter part of Grade 3. In Grades 4 to 5, students learn about area and perimeter. In addition to informal experiences, students begin to develop the formulae for area and perimeter in Grades 4 to 6. Lindquist (1989) found out that students used formulae such as A = L x W or P = 2L + 2W without understanding how these formulae relate to the attributes being measured or the units of measurement being used. NCTM (2000) suggested that teachers must help students see the connections between the formulae and the actual objects. It is our view that, the extent to which primary school children are able to understand the concepts of area and perimeter, depends among other things, on their teachers' content knowledge of the two concepts and the methods used to teach them.

Factors Linked with Student Mathematics Performance

The findings from investigations conducted in different nations of the world have revealed that several factors do contribute to students' poor performance in mathematics.

These factors are either student or teacher related. But several findings about the factors that are believed to be associated with students' mathematics performance have been conflicting. These factors include the differences in the students' gender, cohort or grade level, age, and mathematical abilities.

Hyde, Fennema and Lamon (1990) reported that gender differences in mathematical achievement favouring boys were not found until early adolescence. Nonetheless, they also noted that in terms of mathematical sub-areas, gender differences had been identified depending on which area was being considered. Lummis and Stevenson (1990) pointed out that gender differences favouring boys in tasks like measurement, estimation and the visualisation of geometric figures emerged as early as Grade 1 in countries such as

China, Taiwan, Jamaica and the USA. While evidence from two international studies suggested that the gender differences in high school students' mathematics and science performance up till the 1990s were in the favour of males (Forrest, 1992; TIMSS, 1996), the pattern in school achievement in the English-speaking Caribbean nations appears to be at variance with the international trend. For instance, Miller (1999) noted that all over the Caribbean, girls surpassed, and continue to surpass boys in school achievement at the early childhood, primary and secondary level and that at the tertiary level males continue to hold the advantage only in engineering-related subjects.

We could not find studies that had been conducted on grade level/cohort differences in students' mathematics test performance. However, based on a study conducted on preservice teachers' performance on a biology test, we were able to make some inferences that are likely to be true of grade level differences in students' performance in mathematics. For example, Soyibo (1997) reported that while 67 first year preservice teachers statistically performed better than the 52 second-year and 54 third-year peers respectively on the biological labelling errors test he explored, there were no significant cohort differences in the performance of the second and third year students. We think that the first year preservice teachers' significantly better performance than their second and third year counterparts, might be attributed to the possibility that the concepts tested were among the main focus of the first year students and as such the information tested was more "recent" or "fresher" in their memory than it was in the memory of the second and third year students.

Many researchers have explored the relationship between age and student performance in universities. But a definite answer has not been given to the question, "Do mature students do better or worse than younger students?" Some researchers have shown that whether mature students fared better or worse than younger ones depended on the subject being investigated. Fagin (1971) as cited in Woodley (1980) noted that the older students did worse in science and mathematics than the younger ones. Revealed in the Metropolitan Achievement Test that Fredrick, Mishler and Hogan (1984) administered were the key areas of mathematics in which adults might be at a disadvantage than younger students. On one question set on the area of a circle, they reported that 82% of the younger students and 31% of the older students got the question correct. Nevertheless, we could not find any Caribbean study in which age differences in students' mathematics performance had been investigated.

We found only few studies in which the association between students' mathematical abilities and mathematical achievement was explored. In a study that was focused on the factors associated with low, average and high performers in mathematics, Uttal, Lummis and Stevenson (1988) made the following observations: (a) high achievers in Japan, China and America received higher marks than did the average mathematics achievers; and (b) the average achievers in turn received higher scores than the low achievers. But we were unable to find any study focused on mathematical ability differences in Caribbean students' performance in mathematics.

Rationale for the Study

With the demand and call for mathematics educators to teach students mathematics with understanding (Van de Walle, 2001), it is important that the mathematics knowledge of preservice primary teachers be assessed. It seems obvious that the inadequate mathematics competency of many teachers is likely to lead them to teach their students in a procedure-driven manner, while paying little or no attention to relational understanding (Bell-Hutchinson, 2004). This is because common sense suggests that one cannot give what one does not have.

The National Council of Teachers of Mathematics (NCTM, 2000) emphasised that, measurement concepts - especially area and perimeter - are important components of many school mathematics curricula. The mathematics syllabuses of the CXC for the secondary education certificate examinations (SECE) and the GCE that the Universities of Cambridge and London examine at the O-level require the study of measurement concepts of area and perimeter. Although these two concepts constitute a small portion of the measurement strand, they form a strong foundation in the understanding of concepts such as surface area and volume – concepts that are required (at the secondary level and beyond) for the understanding of biophysical science concepts such as transport mechanisms and the conservation of heat in many organisms.

Whereas many of the studies on the measurement strand had been done with primary school age students (e.g., Rickard, 1996; Moyer, 2001), only a few studies had been specifically focused on preservice primary teachers' understanding of the concepts of area and perimeter. For instance, the studies of Reinke (1997) and Woodward and Byrd (1983) showed that preservice teachers were uncertain about and harboured misconceptions on the two concepts.

Purpose of the Study

This study was conducted to find out (a) if the level of knowledge of the concepts of perimeter, area and area-perimeter of selected Jamaican preservice primary teachers was satisfactory; (b) if there were significant differences in their performance on the three concepts linked to their (i) gender, (ii) cohort, (iii) age, and (iv) mathematical abilities; and (c) if there were significant relationships among the students' gender, cohort, age and mathematical abilities and their performance on each of the three concepts. We considered this decision to be worthwhile because we were unable to find any previous studies in which these variables had been explored with preservice primary teachers of mathematics.

Methodology

Research Design

An *ex post facto* research design was utilised in this study. This was because the study was aimed at establishing if there are significant correlations among the preservice primary teachers' gender, cohort, age and mathematical abilities (called the independent variables) that could not be manipulated as they had already existed and their performance on perimeter, area and area-perimeter (the dependent variables) (Weirsma, 1995).

Sample

The main study's sample comprised 200 preservice primary teachers (aged 16-50 years, comprising 166 females and 34 males), purposively selected from three Jamaican teachers' colleges. To group the participants into mathematical ability categories, their 2004 final year mathematics examinations scores obtained from their lecturers were used.

Participants with scores of 70% and above were classified as having a high mathematical ability; those with scores of 50% to 69% were categorised as having an average mathematical ability; while those with scores below 50% were grouped as having a low mathematical ability. Table 2 shows the detailed demographic data of the participants.

Instrumentation and Procedure

For data collection, the Perimeter-Area-Test (PAT) that we developed was administered to the participants. The test had three sections. Section A had six items used to obtain demographic information about the participants. Section B consisted of 18 multiple-choice items – 6 each on perimeter, area, and area-perimeter. Each multiple-choice item had four options. Section C had 4 structured items, 2 of which were on the mathematical content of area, perimeter, and area-perimeter and the remaining 2 on how to teach the concepts of area, perimeter and area-perimeter. The maximum scores were: 16 for area, 16 for perimeter and 10 for area-perimeter. The test items were constructed based on the objectives from the Joint Board of Teacher Education Mathematics Curriculum for the teachers' colleges, Revised Primary Curriculum (Grades 1-6, 1999), and CXC Mathematics Syllabus (2004).

The pilot study sample consisted of 20 male and 30 female Year 2 and Year 3 student-teachers from three Jamaican teachers' colleges. The multiple-choice items yielded a Kuder-Richardson KR-21 internal consistency reliability coefficient of 0.90 using Ebel and Frisbie's (1991) correction formula for underestimation that may characterize KR-21. We felt satisfied that the multiple-choice items had satisfactory reliability because Miller (1991) opined that reliability coefficients ranging from 0.80 to 1.0 display "very strong reliability". The multiple-choice items' difficulty indices ranged from 0.38 and 0.94. As Ebel and Frisbie (1991) have suggested that test items, with facility indices of 0.30 and above, are regarded as good and acceptable in educational research, none of the multiple-choice items was modified or discarded. The inter-rater reliability coefficient calculated on the scores that one of the authors and an independent marker gave on 10 randomly selected scripts of the students' answers on Section C of the PAT was 0.89. This coefficient indicated that the two markers were very consistent in their use of the prepared marking scheme in grading the students' answer scripts.

Table 1
Means, Standard Deviations, Percentages of Students' Scores on Perimeter, Area and Area-Perimeter

Variables	Mean	%	SD
Perimeter	8.36	52.25	3.15
Area	7.19	44.94	3.52
Area-Perimeter	6.17	61.70	2.21
Total	21.72	51.71	8.88

Maximum: Perimeter = 16, Area = 16, Area-Perimeter = 10
n = 200 in each case

Results and Discussion

The first purpose of this study was to determine if the level of knowledge of the concepts of perimeter, area and area-perimeter of selected Jamaican preservice primary teachers was satisfactory. Table 1 shows that, overall, the student-teachers have a "barely" satisfactory performance on the entire test because their grand mean score (21.72 or 51.71% out of a maximum score of 42) is just above the conventional 50% pass mark. The table indicates that their performance in increasing order of magnitude is as follows: area-perimeter $_{>}$ perimeter $_{>}$ area. This finding was not expected because we had expected that the order of their performance on the concepts from the highest to the lowest would have been: perimeter, area, area-perimeter. We did not expect their overall performance to have been "barely" satisfactory as we had expected their overall mean score on each of the three concepts to be above 60%. These results which showed a"barely" satisfactory performance of the students on perimeter, area and area-perimeter in this study was supported indirectly by CXC's Examiners' Reports on Caribbean 11th-graders' performance in the SECE in mathematics from June 1998 to 2003. These reports highlighted the fact that the candidates demonstrated significant weaknesses in the area of measurement.

We now discuss briefly the students' responses on two of the 18 multiple-choice items to illustrate their "barely" satisfactory performance.

12. The sides of a square are doubled. Which of the following is **True**?

A. Its area is quadrupled. B. Its area does not change.

C. Its area is tripled. D. Its area is doubled.

14. If the area of a square is 49 cm^2, its perimeter is

A. 7 cm B. 14 cm C. 28 cm D. 49 cm

Question 12 required the students to state what would be the effect of the doubling of the sides on the area of the new square that would be formed. But only 46% of the sample realised that the area would be quadrupled. Many of the students did not use their problem-solving skills because even if they had never examined a case like this in class, and if they had drawn a square and doubled the length of each of its four sides, they would have obtained the correct answer. Only 80% of the students scored item 14 correctly, while about 10% of the students chose 7 cm as the correct answer. This seems to imply that these student-teachers regarded perimeter as synonymous with length.

The second purpose of this study was to find out if there were significant differences in the student-teachers' performance on the three concepts linked to their (i) gender, (ii) cohort, (iii) age, and (iv) mathematical abilities. First, the means and standard deviations of the participants on perimeter, area and area-perimeter based on the four independent variables were computed (Tables 2 to 4).

Table 2
Students' Means and Standard Deviations on Perimeter Based on Four Variables

Variable	n	Mean	SD
Gender			
Male	34	8.82	2.42
Female	166	8.26	3.28
Cohort			
Year 2	114	8.49	3.30
Year 3	86	8.18	2.96
Age			
16 - 24	145	7.98	3.06
25 - 29	39	9.56	3.25
30 plus	16	8.81	3.19
Mathematical Abilities			
High	29	11.48	2.47
Average	64	8.68	3.04
Low	107	7.31	2.78

Table 3
Students' Means and Standard Deviations on Area Based on Four Variables

Variable	n	Mean	SD
Gender			
Male	34	7.88	2.59
Female	166	7.05	3.68
Cohort			
Year 2	114	7.45	3.72
Year 3	86	6.86	3.24
Age			
16 - 24	145	6.96	3.51
25 - 29	39	8.19	3.63
30 plus	16	6.91	3.10
Mathematical Abilities			
High	29	9.24	3.90
Average	64	7.70	3.73
Low	107	6.34	3.00

Table 4
Students' Means and Standard Deviations on Area-Perimeter Based on Four Variables

Variable	n	Mean	SD
Gender			
Male	34	6.38	1.88
Female	166	6.12	2.28
Cohort			
Year 2	114	6.39	2.19
Year 3	86	5.87	2.22
Age			
16 - 24	145	6.10	2.15
25 - 29	39	6.72	2.48
30 plus	16	5.44	1.90
Mathematical Abilities			
High	29	7.45	1.82
Average	64	6.51	2.13
Low	107	5.62	2.19

The data in each of Tables 2-4 indicate that (a) the mean of the males is slightly higher than the mean of the females; (b) the mean of Year 2 students is slightly higher than that of Year 3 students; (c) the mean of students aged 25 to 29 years is slightly higher than the mean of students aged 16 to 24 years, and 30 years and above respectively; and (d) the mean of students with high mathematical ability is much higher than that of students with average and low mathematical abilities respectively. In all cases, the standard deviations are relatively low suggesting that there were low variations in the scores of high and low scorers on the three concepts.

To find out if there were statistically significant differences in the means of the students on perimeter, area and area-perimeter based on gender, cohort, age and mathematical abilities, 4-way analysis of variance (ANOVA) was computed and the results are presented in Table 5.

Table 5

Analysis of Variance in Students' Performance on Perimeter, Area and Area-Perimeter By Gender, Cohort, Age and Mathematical Abilities

Concept	Source of Variation	SS	df	MS	F
Perimeter	Gender	3.04	1	3.04	0.38
	Cohort	2.17	1	2.17	0.27
	Age	20.16	2	10.08	1.26
	Mathematic Abilities	334.44	2	167.22	20.82*
	Model	428.99	6	71.50	8.90
	Residual	1550.30	193	8.03	
	Total	1979.30	199	9.95	
Area	Gender	11.76	1	11.76	1.02
	Cohort	2.74	1	2.74	0.24
	Age	7.29	2	3.64	0.32
	Mathematic Abilities	158.90	2	79.45	6.87*
	Model	237.02	6	39.50	3.41
	Residual	2233.38	193	11.57	
	Total	2470.40	199	12.41	
Area-Perimeter	Gender	0.13	1	0.13	0.03
	Cohort	5.75	1	5.75	1.27
	Age	6.25	2	3.13	0.69
	Mathematic Abilities	66.61	2	33.31	7.34*
	Model	99.66	6	16.61	3.66
	Residual	875.98	193	4.54	
	Total	975.64	199	4.90	

* $p < .001$

It can be inferred from Table 5 that there are statistically significant differences in the preservice primary teachers' performance on perimeter, area and area-perimeter based on their mathematical abilities. It is evident from Tables 2 to 4 that the significant differences are in favour of students with high mathematical abilities on each of the three concepts. Table 5 also shows that there are no statistically significant differences in the student-teachers' performance on the three concepts based on gender, cohort and age.

We anticipated the finding that student-teachers with high mathematical abilities will significantly outperform their counterparts with average and low mathematical abilities on the three concepts. Uttal, Lummis and Stevenson's (1988) finding that high school students who were categorised as high achievers actually scored higher than their classmates who were classified as having an average or a low mathematical ability provided an indirect support to this study's finding. But we could not find any previous study in which the correlation between preservice teachers' mathematical ability and their mathematical performance had been investigated with which we could compare this study's finding.

The authors did not expect the findings that there were no significant differences in the students' performance on the three concepts linked to their gender, cohort and age.

For example, we had expected the females to perform significantly better than the males because (a) of the reported diminishing gender gap in students' mathematics achievement (e.g. Alkhateeb, 2001); and (b) from one of the researchers' mathematics teaching experience in a teachers' college, the researchers had observed that female Jamaican preservice teachers were usually more focused and more conscientious in their studies than their male classmates who tended to show scant regard to their studies. We expected the Year 2 student-teachers to perform significantly better than the Year 3 student-teachers because the former had just completed receiving lectures on a module on the three concepts investigated in this study. We had expected the younger student-teachers (16 to 24-year-olds) to significantly outscore the older student-teachers because they had recently left the high school and were expected to have had a more recent memory of the three concepts on which they were tested in this study than their older counterparts. Unfortunately, the authors did not find any previous research that had been conducted on whether or not there were statistically significant differences in pre-service teachers' mathematics performance based on their gender, cohort and age.

The third purpose of this study was to find out if there were significant relationships among the preservice primary teachers' gender, cohort, age and mathematical abilities and their performance on each of the three concepts. Point-biserial correlation coefficients (Table 6) were computed because genuine dichotomies existed among two of the independent variables – gender and cohort (Guilford & Fruchter, 1978).

Table 6
Point-biserial Correlation Coefficients Relating Students' Gender, Cohort, Age and Mathematical Abilities to their Scores on Perimeter, Area and Area-Perimeter

	Gender	Cohort	Age	Mathematical Abilities
Perimeter	0.06	0.05	0.16*	0.44**
Area	0.09	0.08	0.07	0.30**
Area-Perimeter	0.04	0.12	0.00	0.30**

* $p < .05$ ** $p < .001$

Table 6 indicates that there is no relationship between the students' (a) gender, and (b) cohort and their performance on perimeter, while there is a positive, statistically significant but weak relationship between their (c) age and their performance on perimeter. Statistically significant but moderate relationship (r_{pb}=0.44, p<0.01) is found between (d) mathematical abilities and their performance on perimeter. Whereas findings (a), (b) and (d) are consistent with the data in Table 5, finding (c) conflicts with the finding in Table 5 discussed earlier. Table 6 also shows that there is no relationship among the student-teachers' gender, cohort and age and their performance on area, whilst there is a positive, statistically significant but moderate correlation (r_{pb}=0.30, p<0.01) between their mathematical abilities and their performance on area. The table also indicates that whereas there are no relationships among the students' gender and age and their performance on area-perimeter, the relationship between their cohort and performance on area-perimeter is statistically insignificant (r_{pb}=0.12), while the relationship between their mathematical abilities and their performance on area-perimeter is positive, statistically significant but moderate (r_{pb}=0.30, p<0.01). The findings regarding area and area-perimeter confirm the results in Table 6 discussed earlier. The positive, statistically significant but moderate relationship between the students' mathematical abilities and their performance on each of the three concepts suggests that there were other variables apart from the students' mathematical abilities which could have accounted for significant differences in their performance but which were not explored in this study.

Conclusions and Educational Implications

The finding that the preservice teachers' performance on the three concepts was "barely" satisfactory implies that most of them, on the completion of their teachers' programme, are likely to find it difficult to competently teach their students the concepts of area, perimeter and area-perimeter (Jeffrey *et al.*, 1995). To improve Jamaican preservice primary teachers' understanding of and performance on area, perimeter and area-perimeter - so that they can be empowered to competently teach their students -

mathematics lecturers in Jamaican teachers' colleges need to use student-friendly, practical-oriented instructional strategies in teaching their students these three concepts and other concepts, unlike the lecture method that is predominantly used in teaching mathematics in Jamaica (Bell-Hutchinson, 2004).

The finding that students with high mathematical ability significantly outperformed their peers with average and low mathematical abilities suggests that unless many Jamaican preservice primary teachers obtain fairly high grades in the SECE in mathematics before they are admitted into the teachers' college programme, they are not likely to be able to effectively teach their students the concepts of area, perimeter and area-perimeter (Uttal, Lummis & Stevenson, 1988). The findings that there were no significant gender, cohort and age differences in the students' performance on the three concepts seem to imply that Jamaican preservice primary teachers can be taught to learn fairly satisfactorily the concepts of area, perimeter and area-perimeter regardless of the differences in their gender, cohort and age.

Other variables, besides the preservice primary teachers' mathematical abilities, which could have contributed to significant differences in their performance on area, perimeter and area-perimeter - which should be investigated in future studies on this topic - include the differences in the students' subject preference, self-esteem, learning style, socioeconomic background, and language ability, and the differences in their mathematics lecturers' qualifications, teaching experience, and teaching styles.

References

Alkhateeb, H. M. (20001). Gender differences in mathematics achievement among high school students in the United Arab Emirates, 1991-2000. *School Science and Mathematics, 101*(1), 5-9.

Bell-Hutchinson, C. E. (2004). *Teaching-for-thinking*: *The implementation of thinking-focused pedagogy in two grade 8 mathematics classrooms in Jamaica*. Unpublished PhD thesis, University of the West Indies, Mona, Jamaica.

Caribbean Examinations Council (2003). *Reports on candidates' work in the secondary education certificate general proficiency examinations: Mathematics.* St. Michael, Barbados: CXC.

Caribbean Examinations Council (2004). *Secondary education certificate examination*. *Mathematics syllabus*. St. Michael, Barbados: CXC.

Ebel, R. & Frisbie, D. A. (1991). *Essentials of educational measurement* (3rd Ed.). New Jersey: Prentice-Hall.

Forrest, G. M. (1992). Gender differences in school science examinations. *Studies in Science Education*, 20, 87-121.

Franke, M. (2000). Dialogues: How much can we accomplish? Elementary mathematics methods revisited. www.Dialogues/mathlibrary.htm

Fredrick, D., Mishler, C. & Hogan, T. P. (1984). College freshmen mathematics abilities: Adults versus younger students. *School Science and Mathematics*, 84(4), 327-333.

Guilford, J. P. & Fruchter, B. (1978). *Fundamental statistics in psychology and education*. (6th Ed.). London: McGraw-Hill Inc.

Hyde, J. S., Fennema, E. & Lamon, J. S. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin*, 107, 139-155.

Jeffrey, B., Murray, J., Humble, M. & Robinson, D. (1995). Mathematical knowledge and primary teachers: Beyond the deficit model. *British Journal of In-Service Education*, *21*(2), 51-62.

Lindquist, M. M. (1989). The measurement standards. *Arithmetic Teacher*, *37*(2), 22-26.

Lubinski, C. A., Thomason, R., & Fox, T. (1998). Learning to make sense of division of fractions: One K-8 preservice teachers' perspective. *School Science and Mathematics*, *98*(5), 247-253.

Lummis, M. & Stevenson, H. W. (1990). Gender differences in beliefs and achievement: A cross-cultural study. *Developmental Psychology*, 26, 259-263.

Miller, A. (1991). *Handbook of research and social measurement* (5th Ed.). Newbury Parks, CA: Sage.

Miller, E. (Ed.). (1999). *Educational reform in commonwealth Caribbean*. OAS: Inter- amer 54 Education Series.

Moyer, P. S. (2001). Using representations to explore perimeter and area. *Teaching Children Mathematics,* 2, 52-59.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

Reinke, K. S. (1997). Area and perimeter: Preservice teachers' confusion. *School Science and Mathematics*, *97*(2), 75-77.

Revised primary curriculum. Curriculum guide. Grades 1-6. Government of Jamaica/ Inter-American Development Bank. Primary Education Improvement Project (PEIP II) (1999). Kingston, Jamaica: Ministry of Education and Culture.

Rickard, A. (1996). Connection and confusion: Teaching perimeter and area with a problem-solving oriented unit. *Journal of Mathematics Behaviour*, *15*(3), 303-327.

Soyibo, K. (1997). Preservice teachers' knowledge of biological labeling errors. *Journal of Education & Development in the Caribbean*, *1*(2), 152-162.

Stevens, C. & Wenner, G. (1996). Elementary preservice teachers' knowledge and beliefs regarding science and mathematics. *School Science and Mathematics*, *96*(1), 2-3.

TIMSS (1996). *Third international mathematics and science study*. Washington, D.C: US Department of Education.

Uttal, D. H., Lummis, M. & Stevenson, H. W. (1988). Low and high mathematics achievement in Chinese and American elementary school children. *Developmental Psychology*, *24*(3), 335-342.

Van de Walle, J. (2001). *Elementary and middle school mathematics*: *Teaching developmentally*. New York, NY: Longman.

Weirsma, G. (1995). *Research methods in education*: *An introduction* (6th Ed.). Boston, MA: Allyn and Bacon.

Woodley, A. (1980). The older the better? A study of mature student performance in British universities. *Research in Education*, 32, 35-49.

Woodward, E. & Byrd, F. (1983). Area: Included topic, neglected concept. *School Science and Mathematics*, *83*(4), 342-347.