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How the Use of Subjectivist Instructional Strategies in Teaching Multiple Sections of an Eighth Grade Algebra Class in Guyana Relates to Algebra Achievement and Attitude Changes toward Mathematics

Jennifer Hoyte

Florida International University, jhoyte@serenityprojects.com

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FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

HOW THE USE OF SUBJECTIVIST INSTRUCTIONAL STRATEGIES IN
TEACHING MULTIPLE SECTIONS OF AN EIGHTH GRADE ALGEBRA CLASS IN
GUYANA RELATES TO ALGEBRA ACHIEVEMENT AND ATTITUDE CHANGES
TOWARD MATHEMATICS

A dissertation submitted in partial fulfillment of

the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

CURRICULUM AND INSTRUCTION

by

Jennifer Hoyte

2017

To: Dean Michael R. Heithaus
College of Arts, Sciences and Education

This dissertation, written by Jennifer Hoyte, and entitled How the Use of Subjectivist Instructional Strategies in Teaching Multiple Sections of an Eighth Grade Algebra Class in Guyana Relates to Algebra Achievement and Attitude Changes toward Mathematics, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

Tonette Rocco

Mido Chang

Maria Lovett

Maria L. Fernández, Major Professor

Date of Defense: June 28, 2017

The dissertation of Jennifer Hoyte is approved.

Dean Michael R. Heithaus
College of Arts, Sciences and Education

Andrés G. Gil
Vice President for Research and Economic Development
And Dean of the University Graduate School

Florida International University, 2017

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ABSTRACT OF THE DISSERTATION

HOW THE USE OF SUBJECTIVIST INSTRUCTIONAL STRATEGIES IN
TEACHING MULTIPLE SECTIONS OF AN EIGHTH GRADE ALGEBRA CLASS IN
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by

Jennifer Hoyte

Florida International University, 2017

Miami, Florida

Professor Maria L. Fernández, Major Professor

In Guyana, South America, the Ministry of Education seeks to provide universal, inclusive education that prepares its citizens to take their productive places in society and to creatively solve complex, real-world problems. However, with frequent national assessments that are used to place students in high school, college or into jobs, teachers resort to using familiar strategies such as lecture, recitation and test drilling. Despite their efforts, over 56% of students are failing the Grade 6 assessments, 43% failing 10th grade Mathematics and over 60% failing college algebra courses. Such performance has been linked to students' lower academic self-concept and their negative attitudes toward mathematics aggravated by an autocratic culture that continues to view the teacher as sole authority.

Subjectivist instructional strategies integrate constructivism and affect by providing a learning experience that gives children more autonomy as they solve contextually relevant algebraic problems. In a quasi-experimental study involving a

treatment and control group of eighth grade students at a high school in Guyana, a modified version of the Mathematics Value Inventory was used to measure students' attitudes towards mathematics before and after the 10-week treatment. Scores on the final examination were used to determine achievement in algebra.

Forty seven students in the treatment group were guided in exploring and discovering concepts for themselves. Formal definitions were delayed until after the students experimented with relatable scenarios. Forty two students in the control group were taught using multiple opportunities to practice. Analysis was done using General Linear Models to determine the variance in achievement and attitude scores accounted for by the instructional strategies while controlling for sex, challenge index, and, pretreatment scores for attitude and achievement. The challenge index was developed to identify outside influences on students' performance such as: travel time; whether living at home; number in household; sleepiness; noisiness; and, resource availability.

Results were not all as expected but some interesting relationships surfaced between the challenges, attitudes towards mathematics and achievement scores. Ultimately it was determined that the environment in which students had to study and the challenges they faced outweighed the small gains in attitude changes for the treatment group.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
Background to the Problem	2
Problem Statement	4
Purpose of the Study	7
Research Questions and Hypotheses	8
Theoretical Framework	9
Study Variables	12
Significance of the Study	15
II. REVIEW OF THE LITERATURE	16
Attitudes toward Mathematics	16
Challenges Guyanese Students Face	23
Subjectivism in the Mathematics Classroom	25
Characteristics of a Subjectivist Pedagogy	26
Strategies of a Subjectivist Pedagogy	30
Misconceptions in Algebra	36
Algebraic Understanding in Guyana	38
Move to Relational Algebraic Understanding	39
III. METHODOLOGY	45
Purpose of the Study	45
Research Questions and Hypotheses	45
Research Design	46
Statistical Parameter Settings	47
Source of Data	48
Setting	48
Population	50
Teacher Background	51
Power Analysis and Sample Size	52
Procedures	52
Treatment Group Process	53
Control Group Process	59
Observation Process	59
Variables and Instrumentation	60
Predictor Variable	60
Criterion Variables	64
Covariates	65
Data Analysis	67
General Linear Models	67
IV. RESULTS	72
Descriptive Data and Exploration of Challenge Variables	72
Background of the Sample	72

The Challenge Index	73
Attitude Scales	77
Achievement	85
Hypothesis Analysis.....	89
Assumption Testing	89
Analysis of Hypothesis H_1	93
Analysis of Hypothesis H_2	105
Analysis of Hypothesis H_3	110
V. DISCUSSION.....	114
Discussion of the Findings.....	116
SIS and Attitude Scales.....	116
SIS and Achievement.....	120
Effect of Attitudes on Achievement	123
Implications for Practice	125
Limitations of the Study.....	127
Recommendations	127
REFERENCES	130
APPENDICES	141
VITA.....	147

LIST OF FIGURES

FIGURE	PAGE
1. Page of textbook from 1991 (Layne et al., 1991).	39
2. Page of textbook in use in 2015 (Toolsie, 2007).	40
3. Variety of activities for use in the classroom (Ministry of Education, Guyana, 2013d).....	41
4. Suggested classroom activities (CXC, 2015).....	42
5. Mock CSEC mathematics exam.	43
6. Mock CSEC mathematics exam, Section II.....	44
7. Graphics used in discussing positive and negative numbers.	55
8. Comparing positive and negative numbers.....	56
9. Adding positive and negative numbers.....	57
10. Breakdown of sex by study group.	72
11. Challenge index descriptions.	74
12. Correlations between challenge variables.....	75
13. Principal factor analysis of challenge variables.....	77
14. Variance accounted for by challenge index factors.	77
15. Subscale Cronbach Alpha reliability ratings, pre- and posttreatment.....	78
16. Modified MVI before and after scores by group.	78
17. Correlations between modified MVI posttreatment subscales and challenge variables.	80
18. Repeated measures analysis of modified MVI interest subscale.	81
19. Boxplot of relationship between posttreatment utility score and frequency of household chores.....	82
20. Repeated measures analysis of modified MVI utility subscale.	83
21. Repeated measures analysis of modified MVI need for achievement subscale.	84

22. Boxplot of relationship between posttreatment utility score and lack of convenient study area.....	85
23. Test scores over time.	86
24. Repeated measures analysis of achievement.	87
25. Independent samples test of achievement over time.....	88
26. Box plot of relationship between modes of transportation and achievement on Grade 8 exam.	88
27. Homogeneity of variances of dependent variables across study groups.....	89
28. Scatter plots of predictor against criterion variables.....	90
29. Normality tests for criterion variables with normal outcomes highlighted.	91
30. Histograms Showing normal distributions across predictor variable groups.	91
31. Criterion variable Q-Q plots with normal distributions highlighted.....	92
32. Criterion variable Q-Q plots with normal distributions highlighted.....	93
33. Regression analysis of posttreatment interest subscale.	95
34. Truncated coefficient list of posttreatment interest regression analysis.	97
35. Regression model summary for posttreatment utility subscale scores.	98
36. Truncated coefficient list of posttreatment utility regression analysis.	99
37. Regression model summary for posttreatment need for achievement subscore.	100
38. Truncated coefficient list of posttreatment need for achievement regression analysis.....	100
39. Regression model summary for posttreatment personal cost subscale.....	101
40. Coefficient list of posttreatment personal cost regression analysis.	103
41. Scatter plot of regression equation predicted scores and actual scores.	105
42. Regression model summary for posttreatment achievement score.....	106
43. Coefficient list of posttreatment achievement regression analysis.....	108

44. Scatter plot of regression equation predicted scores versus actual post treatment achievement scores.	110
45. Regression model summary for achievement score after attitude scores.	111
46. Truncated coefficient list of regression analysis of attitude change on achievement.	113
47. Changes in attitudes towards mathematics over time.	116
48. Group achievement scores over time.	121

CHAPTER I

I. INTRODUCTION

In my interview with the acting head of the Mathematics Department of a secondary (post-primary) school in Georgetown, Guyana, he shared concerns at the declining scores in mathematics across Grades 7 to 10 (HC, personal communication, April 5, 2016). A similar concern was echoed by the former Assistant Chief Education Officer as he spoke of low pass rates in mathematics on the national assessments and school-leaving exams in Guyana (J. McKenzie, personal communication, June 19, 2014). For example, in Grade 6, students sit the National Grade Six Assessment (NGSA), the results of which determine which secondary school students will attend. The mathematics component of the NGSA examines mostly arithmetic and basic geometry, yet only 43.9% of the participants scored over 50% in 2013 (Ministry of Education, Guyana, 2013c).

Looking across the grades at HC's secondary school in Guyana, his cause for concern is readily apparent. From the earliest colonial days under British rule, students get their first look at algebra at the end of the seventh grade (Cameron, n.d.; Chin, 2001). Not surprisingly, with the addition of algebra's variables and symbols the average on the end-of-year mathematics examinations went from 63% for the 2015 Grade 7 students to 59% at the end of Grade 8 in 2016 (HC, personal communication, April 5, 2016). The falling average is evident across the higher grades as the percentage of students below the 50% passing score in mathematics continued to rise. A similar statistic is seen in the Trends in International Mathematics and Science Study 2011 (TIMSS) where among 63

countries around the world, 69% of the students in Grade 8 earned an average algebra score below the scale centerpoint (Mullis, Martin, Foy & Arora, 2012).

Students in algebra courses seem particularly at risk for future failure (Mireles, Offer, Ward & Dochen, 2011; Taylor, 2008) as, at college level in Caribbean countries and other countries worldwide, success in algebra is typically required for advancement to higher educational achievements (Mireles et al., 2011; Singh & Allicock, 2015). With the algebra failure rate at college level continuing to hover over 60% at U.S. and Caribbean universities (Blair, Kirkman & Maxwell, 2013; Green-Evans, 2005), algebra and, more generally, mathematics courses then become the gatekeeper determining who qualifies for higher-level jobs (Moses & Cobb, 2001; Tice, 1997) or a higher education (Stinson, 2004).

Background to the Problem

In the 2011 Trends in International Mathematics and Science Study report (Mullis et al., 2012), only 71% of eighth grade students on average could evaluate a simple algebraic expression such as “ $y = \frac{a+b}{c}$ where $a = 8, b = 6, c = 2$ ” (p. 123) and only 65% could interpret the operations in an expression involving multiplication and addition such as “What does $xy + 1$ mean?” (p. 126). As the type of problems progressed to solving an inequality, such as $9x - 6 < 4x + 4$, the international average dropped to 17%.

This pattern of increased failures at higher levels was also reflected in the Mathematics General Proficiency portion of the Caribbean Secondary Education Certificate (CSEC) Examination that students took in the 11th grade in 2014 in Guyana, South America (Caribbean Examinations Council, CXC, 2014, May/June). The Structured Questions section of this examination consisted of eight required and three

optional questions that students were required to answer in detail, showing all work. In this section, three of the required eight questions and one of the optional three questions tested the students' understanding of algebra.

In 2014, the average overall CSEC mathematics examination score nationally was around 42% with only 50% of the students exhibiting what was considered a “fairly good” to “comprehensive grasp of the key concepts, knowledge, skills and competencies required by the syllabus” (CXC, n.d.). As the complexity of these questions increased, fewer students attempted the problems and the overall average score decreased. For example, the basic required algebra question involving simplifying algebraic fractions or writing equations was attempted by 99% of the candidates. The average score earned on the solution of the problem was 47.4% of the highest possible score. The more advanced required question involving graphs was attempted by 80% of the candidates. The average score earned was 23.5% of the highest possible score. The even more advanced question, from the optional section, involving functions and relations, was attempted by only 73% of the candidates. The average score earned was 45.7% of the highest possible score (CXC, 2014).

Such performance among Caribbean students has been linked to low academic self-concept and negative attitudes towards mathematics (Bentt, 1971; Bowe, 2012). Similarly, in Greece, Skouras (2014) found significant positive correlations between students' attitudes towards mathematics and their algebra achievement scores.

Low academic self-concept seems to go along with low achievement which in turn leads to more negative attitudes giving rise to a destructive cycle of non-performance (Grootenboer & Hemmings, 2007). Lower achievement can be brought on by procedural

misconceptions stemming from the way mathematics is presented in arithmetic and carried over to algebra (Welder, 2012). For example, students may view the use of brackets (or parentheses) as determining the order of operations as opposed to a way of grouping expressions. They may also consider an equal sign to be an indication that the answer follows instead of seeing it as an equivalence operation.

Negative attitudes were also attributable to the teaching styles in use. Prendergast and O'Donoghue (2014) highlighted the low percentage (32%) of students at schools in Dublin, Ireland, who looked forward to or enjoyed their mathematics lessons. With the application of different teaching styles that triggered situational and individual interest in algebra topics, students expressed significantly greater levels of enjoyment of the course. At four high schools in Guyana, Etwaroo (2011) found that 45% of students in Grade 10 had negative attitudes towards mathematics along with low, failing performance in mathematics courses. Students reported being unmotivated and frustrated stemming from teachers being unwilling to answer questions, review material or take time to develop students' understanding. Such reported lows in motivation, interest and confidence in doing mathematics were matched by low scores on the national assessment test.

Problem Statement

The culture in Guyana has tended to be autocratic with parents not seeing the need for students to be given opportunities to make decisions or to question adult decisions (Ministry of Education, Guyana, 1980; Williams, 2011). Such a culture has been reflected in authoritative teaching strategies on the basis of viewing children as *tabulae rasae* who are expected to just accept the teacher's word: lecture/expository teaching, verbatim note-taking as the teacher dictates, and rule-based information transfer.

According to McCloskey (2013), the ritual of teaching and learning mathematics is “based on important shared beliefs about the nature of mathematics and the role of the teacher” (p. 20). In other words, students have an expectation of how mathematics will be taught, teachers expect that learning will take place in certain ways, and these expectations are not easily dislodged. Indeed, from as far back as 1980, the Ministry of Education in Guyana has reported that its teachers believed that they should take a more integrated teaching approach using methods geared to individual children, and, that students should practice working co-operatively. Yet, in 1994, the teachers were found to still be using the same lecture-based methods (Wolff, Schiefelbein, & Valenzuela) resulting in *chalk-and-talk* being the preferred method of information transmission in 2014 (Pestano-Moonsammy, 2014).

In an effort to assuage the flow of students to the failing, leave-school-early group, national assessments at Grade 2 and Grade 4 levels were introduced. Originally, these national assessments were meant to be formative in hopes of early-detection of issues with Mathematics and English, as reported to the Stabroek News (LaRose, 2003). Students were then to be given the necessary remedial treatments so that they could move on to the next grade (Ministry of Education, Guyana, 2013a), and, be more prepared for the NGSA.

Over the years, the Ministry of Education in Guyana also advocated the use of a variety of methods for teaching mathematics. From as early as 1993, teachers were included in discussions of the use of inquiry teaching methods (Grainger, 1993). Later on, Interactive Radio Instruction was introduced during which students hear characters posing questions and have to respond to the suggestions given, thereby demonstrating the

necessary skills and procedures for solving the problems (Guyana Chronicle, 2007a). Students then got practice time with the teacher. Television channels that offer educational programs 24 hours a day in mathematics and other subjects have been available (Ministry of Education, Guyana, 2016) for use in the classroom or at home. The use of continuous assessment was also encouraged whereby teachers use diagnostic interviews and multiple formative assessments in preparation for the national assessments (Guyana Chronicle, 2007c).

However, the decision was made to include a portion of the scores from the Grade 2 and Grade 4 assessments with the National Grade Six Assessment to determine which secondary school a student could attend (Haynes, 2003). Sample exams and questions were then made available on a regular basis for practice. What was meant to be a formative exercise resulted in teaching styles going from *chalk-and-talk* to *drill-and-kill* (Cameron, 2014) and gave rise to an after-school-lessons culture (Menefee & Bray, 2015). After attending school all day, students were expected to remain after school for lessons and to attend school on Saturdays for more lessons. The culture is now so deep-rooted that even parents feel that if their children are not involved in after-school lessons then they are missing out on the education ritual.

Some benefit was seen following the implementation of these initiatives as students' achievement scores rose on the various assessments (Guyana Chronicle, 2007b). However, average scores on both national and regional assessments remain below the Caribbean regional average (Guyana Chronicle, 2015) and students continue to exhibit extremely negative attitudes towards mathematics (Caribbean360, 2016). These negative attitudes have been attributed to teachers not consistently using inquiry teaching

methods either because of teaching-to-the-test or simply because they did not have the necessary materials or technologies (Ministry of Education, Guyana, 2016). In higher grades there has been greater emphasis on preparing students for the school-leaving examinations so teachers have reported reverting to the *chalk-and-talk* method because that is how they learned mathematics (Cameron, 2014), or, long term plans have not always been in place for supporting or providing materials for other teaching methods (Ministry of Education, Guyana, 2016).

Although a variety of teaching methods was being advocated by the Ministry, these methods were all focused on finding different ways of transmitting the concepts as opposed to engaging students in mathematical explorations to discover the concepts for themselves as argued by Moses and Cobb (2001). No attention was given to how students were feeling about mathematics or to bolstering their self-confidence. Additionally, there was no documented research on how well students in Guyana would accommodate a teaching style that was less teacher-authority centered or that gave more autonomy to children not only to have fun with math but also to explore the concepts as they worked co-operatively.

Purpose of the Study

The purpose of this quantitative study was to investigate how the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana was related to achievement in algebra and attitude changes towards mathematics. Subjectivist strategies cater to both the cognitive and affective needs of students as they learn mathematics (Bastick, 2000). Activities and problems

selected involved scenarios to which students could relate. They were also encouraged to discover and analyze concepts instead of just accepting what the teacher said.

Research Questions and Hypotheses

Two research questions guided the present study: (a) What is the relation between the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana and the students' attitudes towards mathematics? and (b) What is the relation between the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana and the students' achievement in algebra? These relationships were investigated while controlling for sex, as research over the years gave some indication of a difference in attitudes and achievement scores between boys and girls (Aiken, 1970; Mullis et al., 2011; Skouras, 2014). There are also many challenges faced by Guyanese children as they pursue an education, such as the long distance they have to travel to get to school, the noisiness of the surroundings, whether or not they are living at home, or having many chores to do. These challenges were also controlled for as research has found relationships between these conditions and students' wellbeing (e.g., King, Mitchell, & Hawkins, 2010). To explore these questions, three hypotheses were tested:

H₁: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment attitude scores towards mathematics, when controlling for sex, challenges and pre-treatment attitude scores.

H₂: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in

predicting posttreatment achievement in algebra when controlling for sex, challenges and prior mathematics achievement scores.

H₃: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment achievement in algebra over and above what is predicted by a difference in attitude scores towards mathematics when controlling for sex, challenges and prior mathematics achievement scores.

Theoretical Framework

Many factors have contributed to the persistent findings of negative attitudes and low achievement in mathematics. Students in Guyana have highlighted the way mathematics is taught as being a significant contributing factor (Etwaroo, 2011). Indeed, emphasis on theoretical abstractions in mathematics can create a dichotomy between theory and practice thereby obscuring the relevance of schooling to daily life (Kliebard, 1965). Stinson (2004) spoke of “transform[ing] gatekeeping mathematics from a discipline of oppressive exclusion into a discipline of empowering inclusion. ... transforming mathematics from a discourse of transmitting mathematics to a ‘chosen’ few students, into a discourse of exploring mathematics with all students” (p. 15). The transformative process can happen when the educator goes beyond simple examples of how mathematics is applied to how people think about mathematics, to how learners can make use of mathematics on a daily basis and how these uses and school learning can be connected (Kilpatrick, 2008).

What better place to start addressing students’ attitudes than in the classroom? Geist (2010) shared that “we must look for environmental variables to explain the

intertwining outcomes of poor achievement and negative attitude toward mathematics” (p. 127). Erickson and colleagues (2008) found the “need to look much more closely and thoroughly at the conditions within school life itself, in which students affiliate and disaffiliate with the project of school learning” (p. 207). Turner and colleagues (2002) spoke of the need to provide a classroom environment that is high-mastery / low-avoidance by providing not only cognitive support but also focusing on motivational and affective support.

Constructivism was introduced around 1987 by von Glasersfeld (Liu & Chen, 2010), on the basis of principles espoused by Jean Piaget, as a way to include the student in the learning process. Students were encouraged to derive conclusions for themselves (von Glasersfeld, 2001) instead of just waiting like an empty bucket to be filled by the teacher. As research progressed to understand what experiences students would base their ideas on, the concept of social constructivism was conceived (Liu & Chen, 2010). Social constructivism, on the basis of Vygotsky’s social learning theory, recognized that social interaction plays a role in students’ learning. From this, the idea of students working in cooperative learning groups was formed (Applefield, Huber, & Moallem, 2001). It was hoped that students would encounter others within a similar development zone, as espoused by Vygotsky (1934), from whom they could learn, without feeling overwhelmed or threatened. Further research also showed the benefits of *situated learning* whereby information is encountered in situations similar to what one would find in the real world (Ackermann, 2001).

The use of constructivist teaching methods has met with mixed success. For some the results showed significant increases in engagement and problem-solving ability

(Carpenter & Fennema, 1992; Hussain, Lindh, & Shukur, 2006). For others, initial implementation did not work well (Liu & Chen, 2010), possible because constructivism targets the cognitive aspects of pedagogy, overlooking the strength of affective learning modes (Williams & Ivey, 2001). Thus, students may be attaining higher achievement scores but remain disaffiliated with school mathematics.

Indeed, some aspects of these early theories were not tapped. For example, Piaget spoke of the disequilibrium that occurs when new knowledge is not immediately assimilated into an existing framework (Piaget, 1964). Disequilibrium is not simply a reflex that goes into action. Rather it is an emotional reaction that triggers a further analysis of the new information and a restructuring of the framework to accommodate it, as observed by Furinghetti and Morselli (2009). Advances in neuroscience show that human intelligence can be shaped and has multiple dimensions: physiological, social, emotional, constructive, reflective and dispositional (Dickmann & Stanford-Blair, 2009). These dimensions work together to organize and reorganize the brain as learning takes place (Brandsford, Brown, & Cocking, 1999). For learning to occur, however, the brain needs to be focused on what is to be learned (D'Angelo, 1998). As the brain pays attention, the patterns of meaning for the new information are created for use by the constructive dimension (Connell, 2009). The emotional dimension interacts with the reasoning component of the social dimension to evaluate the importance of the information so that it can prepare the brain and body to respond accordingly. It will also seek to sustain interest so that necessary learning processes can be completed within the brain.

Finding the right balance between cognitive and affective support is embodied in the paradigm of *subjectivism* (Bastick, 2000). Bastick stressed the need to integrate constructivism and affect by addressing the “subjective experience of learning” (p. 245). The subjective experience encourages the social, affective processes that enhance students’ enculturation and empowerment: “Enculturation into the skills, understanding and values of their subject and empowerment to become self-directed life-long learners” (p. 246). Such enculturation, in the vein of social constructivism, provides situations or contexts to which students can relate from their peer groups and communities outside of school. Empowerment, on the other hand, appeals to the affective processes by allowing students to interact with each other and giving them opportunities to self-express. At the root is the aim of enabling students to “do mathematics” as espoused by the National Council of Teachers of Mathematics (2000).

Study Variables

On the basis of the above framework, the present study measured how the use of subjectivist instructional strategies related to predicting criterion variables of algebra achievement and attitude towards mathematics.

Predictor Variables

Subjectivist interactive strategies were used in the present study to predict achievement in algebra and a change in attitude towards mathematics. Subjectivist strategies need to target the standards of students (a) understanding patterns and relations; (b) using multiple representations with appropriate algebraic symbols; (c) modeling algebraic relationships; and (d) analyzing change (National Council of Teachers of Mathematics, NCTM, 2000). Methods used need to include activities that (a) are

exploratory, (b) are interactive, (c) allow discussion and communication opportunities, and (d) require solving contextual problems (NCTM, 2000).

There are other variables that may predict achievement. Quinn, Youn and Fitch (2011) proposed three areas surrounding the student, course setting and course content. Variables related to the student include differences in grade level, age, sex, socioeconomic status (SES), and, prior ability with algebra. Since the students were from the same grade level, they were within 1 to 2 years of each other, so grade level and age were not included in the present study. Sex was controlled for as TIMSS (Mullis et al., 2012) indicated that the average performance of the girls at 47.6% was significantly higher than that of the boys at 46.4%. Similar differences have been documented for Caribbean children (Ministry of Education, Jamaica, 1962; Ministry of Education, Guyana, 1980). The Ministry of Education in Guyana (1980) found that students' attitudes towards themselves, school and the teachers correlated significantly with their achievement in various subjects. Although the boys' average achievement of 52.2% was higher than the girls at 45.9%, the girls' attitudes to school and self were more highly correlated to their achievement.

Many studies have shown a relationship between socioeconomic status (SES) and achievement (George, 2012; Mullis et al., 2012). The SES looks at the levels of education, income and occupation of a group or individual on the basis of consideration of variables such as parents' education, access to educational resources or access to meals (American Psychological Association, APA, 2017). According to the United Nations Development Programme (UNDP, 2016), 27% of Guyana's population lives at or below the multidimensional population index, with severe deprivations in health, education and

living standards. It was therefore necessary to go beyond the SES to identify specific challenges that Guyanese students face, and how these challenges affect their education. As such, the present study included a survey to identify these challenges, then controlled for the effects of these challenges in determining achievement and attitude towards mathematics.

With regard to course setting in the present study, students attended the same school. They worked in different classrooms but under similar conditions. Course content was an integral part of the present study. The study took place at the beginning of the school year after students had completed a term of algebra in the prior grade level. Thus, prior algebra ability was measured by their Grade 7 scores on the end-of-year mathematics examination.

Criterion Variables

Students' future association with mathematics is shaped by their attitudes towards mathematics and the value they see in it (Skouras, 2014). Thus, the present study used a modified form of the Mathematics Value Inventory (MVI, Luttrell et al., 2010) to gauge changes in students' attitudes as they experimented with algebra.

Traditionally, quizzes and examinations have been used as indications of achievement in mathematics (Ma, 1995; Shirvani, 2009). At the school setting for the present study, there are periodic quizzes, tests, an examination and other assignments on which students are graded in the mathematics course. Therefore, during the term of the present study there were three (3) tests administered with the third test being comprehensive. The same tests were given to all students. Scores on the last algebra test were used as an indication of achievement attained by students.

Significance of the Study

As evidenced by the scores on the school-leaving examinations in Mathematics in Guyana (CXC, 2014, May/June), students have been floundering in mathematics and turned off from pursuing degrees that involve mathematics. Strategies are already being put in place by the Ministry of Education in Guyana to counter this trend (Carrington, 1993; Wintz, 2009), and, the Minister of Education has declared that teaching efforts must focus on developing critical and higher-level thinking:

the practices of drilling and teaching to the test, which had been adopted over the years will do little to benefit pupils in this new dispensation. Work will be continued throughout the system to ensure that teachers focus on fully teaching the appropriate concepts and raising pupils' competence levels, rather than employing the antiquated traditional approaches (Ministry of Education, Guyana, 2016, July 6).

The present study adds to the literature of how students in Guyana responded to a classroom environment that is less autocratic and more focused on student-centered activities. The present study also provides insights into how students adapted to this strategy, if at all. Thus, teachers will have more guidance, and may be more encouraged to fulfill the teaching improvement program objective in the new Strategic Plan (Ministry of Education, Guyana, 2016).

CHAPTER II

II. REVIEW OF THE LITERATURE

Mathematics continues to be a subject that is feared or loved. When letters are used to represent variables in algebra then the purpose of mathematics in everyday life becomes even more obscure. From as far back as 1969, Sawyer discussed the issue of even mathematics teachers being overwhelmed in dealing with algebra. Dreger and Aiken (1957) spoke of the anxiety faced by college students as they approached mathematics. Negative attitudes towards mathematics have been traced back to learned traits developed from the first grade (Aiken, 1970; Geist, 2010) compounded by the unwillingness of teachers to explore student-centered strategies (Etwaroo, 2011; Orhun, 2013) and misconceptions students developed as they tried to use arithmetic concepts to understand algebra (Welder, 2012). The result was failure rates over 50% in algebra (Caribbean360, 2016; CBMS, 1992), and students avoiding mathematics-related careers (Betz, 1978).

Attitudes toward Mathematics

How students feel about mathematics seems inexplicably tied to their achievement. Though causality has not been determined, many studies have found some statistical significance in the relation between more positive attitudes towards math and higher achievement in the subject (Etwaroo, 2011; Ma & Kishor, 1997). The relationship goes the other way also in that lower achievement in mathematics was related to less positive attitudes towards mathematics. As students advanced to the higher grades, the correlation between mathematics achievement and attitude became less significant but

achievement was found to be higher for students who had maintained positive attitudes towards mathematics from their younger years (Aiken, 1970; Ma & Kishor, 1997).

At the junior high school level before students are able to push through to achieve despite negative feelings, attitudes towards mathematics are particularly noticeable (Ma & Kishor, 1997). Such feelings can be exhibited by how students respond emotionally, and how they behave when faced with mathematics (Skouras, 2014). Students can be quite specific about how they feel about school and the factors that encourage affection or disaffection. In a study done by Bentt (1971) involving 2300 students from grades seven, nine and 11 at private and government schools in Guyana, a questionnaire of incomplete sentences was used to gather information about various aspects of schooling.

For example, students had to complete sentences such as: “(1) School has so much ... ; (2) Even if school ... ; (3) Subjects at school that ... ; (4) School rules make ... ; (5) School would be a better place if ... ; and, (6) When certificates are no longer needed for jobs, schools ...” Responses were then analyzed and the following themes emerged: Certification, Curriculum, Examinations, Home Influence, Physical Environment, Attendance, Punishment, School-job Nexus, Rules and Restrictions, School organization and administration, Student conduct and appearance, Teacher adequacy/efficiency, and Teacher/pupil relationship.

In the area of certification, less than 3% of the respondents saw the need to attend school or study hard if they did not need to get a certificate. Yet over 21% of the respondents felt school was necessary to learn what was needed to get a certificate to use when job-hunting. With regard to the curriculum, English and Mathematics were listed most often by both boys and girls as being liked. Surprisingly, Mathematics was listed

by 44% of the girls but only 36% of the boys. However, 3% of the girls responded unfavorably to mathematics compared to 1% of the boys. Students indicated their liking mathematics because of “good teaching” (p. 35) and when the information was relevant to what is happening around them. However, 9% of the participants indicated the need for more interactive, enjoyable activities instead of just “class-room teaching” (p. 14). Bentt (1971) summarized his findings as students are willing to endure quite a bit in order to gain a certificate, yet there is an overall disaffiliation as found by Erickson and colleagues (2008).

In a study involving 960 Grade 9 students across 23 schools, the Ministry of Education (1980) in Guyana sought to find out what students thought and felt about their school experience and how this related to achievement in basic courses like English Language and Mathematics. In particular, they were looking for variances in achievement in each course on the basis of their attitudes. Schools and students were randomly selected and a questionnaire was used to measure their attitudes towards school, teachers and themselves. The measure of attitudes towards school made statements related to how interested students were in their work and how they felt about school as a whole. Using a Likert Scale, students had to indicate if they Strongly Agreed, Agreed, were Undecided, Disagreed, or Strongly Disagreed with each given statement. Statements were a random mixture of favorable and unfavorable items. Average ratings showed that students had favorable attitudes towards school indicating that they looked forward to going to school and did not consider it restrictive. Eighty-nine percent of the students indicated that they liked doing homework but only 79% agreed that they would not try to avoid doing homework.

Although 84% of the students found teachers made classwork interesting, 69% felt that teachers did not provide an environment where all students felt comfortable asking questions or taking part in discussions, and 25% felt nervous when talking to the teachers (Ministry of Education, Guyana, 1980). Despite these seemingly positive attitudes towards homework and classwork, the average mathematics achievement score was still only 48%. Analysis of correlations for the boys and the girls showed that their attitude towards school, teachers and self, contributed significantly to their mathematics achievement scores at $p > .01$. However, although the girls had more positive attitude ratings than the boys, their average score on the mathematics achievement scale, at 45%, was lower than that of the boys at 52%. So, it would appear that gender did not play a role in the relation between students' attitudes and mathematics achievement.

Aiken and Dreger (1961) found that for women, the measure of their attitude seemed to be a better predictor of their performance. Through the use of regression analysis between the combination of attitude scores and high school mathematics grades for 67 women and 60 men, and their achievement scores at the end of a freshman mathematics course, attitude scores were found to contribute the highest significant variance for the women at $p < .01$. For men, the most significant contributor to achievement was the high school mathematics grade. The contribution from attitude scores was not significant. The application of the same regression equation to only the 42 men and 20 women who took the algebra freshman course produced predicted grades for the women that correlated significantly at .65, but correlated at .69 for the men with no significance. The application of these results to the Ministry of Education, Guyana (1980) study would indicate that a higher achievement score may be predicted for the

girls with more favorable attitudes but with the overall average for the girls being just 45%, it still may not be sufficient motivation to earn a passing grade.

Skouras (2014) collected questionnaire responses from 735 students at 37 public junior secondary schools in Greece. Questionnaire items solicited information about how much students agreed with enjoying learning mathematics and its perceived utility. Results showed that girls exhibited slightly less favorable attitudes towards mathematics although their prior mathematics achievement levels were slightly higher than the boys. The differences were not significant. Nevertheless, the attitude score accounted for 18.1% of the variance in the final algebra achievement score (with significance at $p < 0.001$ level), whereas, the prior mathematics score contributed the most significant amount of variance at 44.9% (also with significance at $p < 0.001$ level). Conversely, students' prior mathematics achievement contributed the highest significant amount of variance at 8.1% to their attitude scores ($p < 0.001$). Second was the instructional strategies used at 6.9% ($p < 0.001$) indicating that the teaching strategies played some part in determining not only the attitudes towards mathematics but also the final algebra achievement score. Thus, Skouras recommended increased diversity in strategies to attain higher attitude and algebra achievement score levels.

For 120 tenth grade students from four schools in Guyana, a readily apparent correlation between attitude towards mathematics and mathematics achievement was found (Etwaroo, 2011). Students were given questionnaires to be answered following a Likert scale where *always*, *often*, *sometimes* and *never* indicated how often they experienced the indicated behaviors or feelings. The survey was reviewed by various experienced professionals from the University of Guyana and educational offices, and

tested out with a reliability coefficient of 0.8 to 0.9. Included on the survey were questions such as: In mathematics classes I am afraid to make mistakes; I am afraid of mathematics tests; I like mathematics; I am not the type to do well in mathematics; Mathematics class is frustrating for me. An average overall score of 1 indicated a very negative attitude, 2 was considered negative, 3 was considered positive and 4 was considered a very positive attitude (Etwaroo, 2011).

Performance was measured using the results of the mathematics portion of the 2009 National Grade Nine Examination. Scores between 40 – 55% were considered Poor, 56 to 65% were Fair, 66 – 75% were Good and over 75% were Excellent (Etwaroo, 2011). Analysis showed 73.5% of those with Poor performance also had an average overall negative attitude score. Those with Fair performance were split between 56.5% of them showing negative attitude scores and 43.5% positive. Good performance students were predominantly positive with 73% indicating positive attitudes and 18.9% choosing very positive. Of those with Excellent performance, 66.7% indicated very positive attitude scores. Chi Square analysis showed significance at $p < .001$, and the contingency coefficient of 0.543 indicated a high moderate correlation between overall attitude to mathematics and mathematics performance.

Closer analysis by Etwaroo (2011) indicated that students who held positive beliefs about mathematics (disagreed with “I am not the type to do well in mathematics”) also had overall positive attitudes towards mathematics. Furthermore, those who felt more strongly that they could do mathematics (disagreed with “Mathematics class is frustrating for me”; “I am afraid of mathematics tests”; “I get bored while studying mathematics”) also had more overall positive attitudes towards mathematics. However,

many of those who had overall positive attitudes about mathematics also expressed negative feelings about it (agreed with “In mathematics classes I am afraid to make mistakes; I am afraid of mathematics tests”) indicating that although they were interested in doing mathematics, they were unmotivated and frustrated by the experience. The frustration was attributed by the students to the teaching styles and strategies in use by the teachers (answers to questions such as: “My teacher allows me to ask questions”; “My teacher is always willing to help me work math problems [at] any time after math lessons”; “My teacher complements me when I do good work”; “My teachers give many examples”; “My teacher provides real life experiences when teaching new topics in mathematics”).

Comparison between student ratings of teachers in the Etwaroo (2011) study and how teachers rated themselves turned out to be similar. A Likert scale with options of *always*, *often*, *sometimes* and *never* was assigned numeric values so that the most favorable option was assigned to 4, and the least favorable was assigned to 1. The average was then found of each student’s ratings, and each teacher’s ratings. A value between 3 and 4 showed the teacher was more fair and positive in teaching style; 1 – 2.9 was considered authoritarian or laissez-faire. Results showed students’ average rating to be 2.80, while teachers’ rating was 2.81 – borderline authoritarian but with some democratic leanings. Analysis of individual items indicated agreement that many of the teachers were not open to questions from the students and did not take the time to give sufficient examples or to review homework. These are strategies that students care about as they seek support in their efforts to do mathematics.

Such a lack of motivation in both the students who exhibited good or even excellent performance and those who reported negative attitudes towards mathematics highlights the requirement to provide support for the affective needs of students. The students themselves are calling for greater interaction in their learning (Bentt, 1971); for a variety of strategies (Skouras, 2014); for a student-centered environment (Ministry of Education, 1980); and examples to which students can relate (Etwaroo, 2011). These are some of the ideas classified as subjectivism by Bastick (2000).

Challenges Guyanese Students Face

With 28% of the population classified as living below the poverty level with serious deprivation in living standards, health and education (UNDP, 2016), Guyanese students face many challenges as they attend high school. From where they have to live, to whether they eat, the types of transportation used to get to school or having an environment that is conducive to studying, each new day brings fresh challenges. Much research has been done on these issues for children in many countries. For example, King, Mitchell and Hawkins (2010) looked at how residing with non-parental caregivers related to adolescent well-being. In particular, they examined data from the National Longevity Study of Adolescent Health for U.S. households with nonresident, living biological parents; just one or no parent, grandparents, aunt, uncles or siblings as caretakers; or other nonrelatives; to see how involved nonresident parents were and how the children internalized or externalized problems. Internalizing problems were defined as unhappy feelings, or low self-esteem. Externalized problems were measured by how often the children engaged in delinquent behaviors including lying; antisocial behaviors; or exhibiting violence.

King and colleagues (2010) found that children living with extended family exhibited more external problem behaviors ($B = .71, p < .05$ in a regression predicting problem behavior from living arrangements) and those with non-family exhibited the highest internalizing of problems ($B = .53, p < .05$). Similarly, in a study involving 235 Grade 8 students in six urban and rural schools in Kenya, Muola (2010) found significant correlations between not only the parents' education ($r = 0.14$), but also the family size ($r = 0.26$), and the learning facilities in the home ($r = 0.23$).

Dealing with living arrangements is critical for each Guyanese child. Access to secondary schooling in Guyana is determined by the results of the National Grade Six Assessment (NGSA, Ministry of Education, Guyana, 2013b). Top scorers will go to one of the five leading "6th Form" high schools. These are located in Georgetown, the capital city, and provide schooling from Grade 7 to Grade 13. In Grade 13, the highest level of school-leaving examination, the Caribbean Advanced Proficiency Examination (CAPE), can be taken for admission to university or higher level jobs. Once the leading schools are filled, students are then placed into List A through List C high schools as determined by cutoff scores on the NGSA and place of residence. These schools support education through only the required Grade 11, at which point students are allowed to take the Caribbean Secondary Education Certificate (CSEC) examination. Needless to say, parents target one of the leading schools for their children, even if it means finding accommodation within Georgetown for the duration of school. Therefore, some children may end up having to live with extended family, friends or even guardians while they attend high school. Even those living at home may need to commute over 2 hours each way to get to school each day.

Other challenges faced by Guyanese children include the noise level: at school - walls do not go to the roof and some children can be quite boisterous and loud-spoken; at home - walls and floors are paper-thin so any disturbance can be heard from several houses away; students live in households with as many as 10 or more people, so study space may be limited; adults may rarely be home as it takes both parents working to even eke out an existence so homework help may not be available; many children are expected to help with household chores including washing, fetching water, or looking after other siblings or sick relatives; blackouts are frequent and could last for hours; and, many do not have assigned textbooks or may not be able to afford them.

For students involved in the Michelson (1968) study, noise was found to affect them in the areas of spelling, creativity and language. Noise could also easily have affected mathematics performance in areas of applying what they knew to new problems. Michelson went further to determine that the higher scoring students had designated areas for studying. Although it was expected that students living with more people in a home would not perform as well, what was noted was that how the space in the home was allocated was more critical to achievement. That is, if students had designated study areas and the communal areas were respected as such so that no distracting activity was performed in those areas, the achievement of the students was not affected.

Subjectivism in the Mathematics Classroom

Subjectivism is defined as “an affect-structured constructivist pedagogy” (Bastick, 1999, p. 1). As constructivism challenges students’ cognition by involving them in activities that encourage them to create associations between what they already know and what they are learning (Benn, 2010; Gorrell, 1992) so subjectivism deliberately

targets students' interests and emotions by incorporating activities that build motivation and excitement in the subject matter (Bastick, 1999). Such activities need to be “authentic affective/cognitive learning experiences” (p. 2) that act as learning multipliers. As students find personal meaning in the material, they focus on it longer (Connell, 2009), thereby providing opportunity for deeper processing and enhanced associations for greater retention (Gorrell, 1992).

Catering to affective factors in the learning of mathematics has received wide research coverage (e.g., Aiken, 1970; Erickson et al., 2008; Grootenboer & Hemmings, 2007; Ma, 2006; McLeod, 1987). As the underlying factors for attitude towards mathematics have been isolated, the scales for measuring these factors have also been refined resulting in more precise correlations between affect and achievement (Aiken, 1970; Grootenboer & Hemmings, 2007; Samuelsson, 2011). Various educational bodies are also encouraging the use of contextual, relevant material and stressing the need to help students see the major role played by mathematics in other subject areas and the real world (APA, 1997; NCTM, 2000; OECD, 2004).

Characteristics of a Subjectivist Pedagogy

In a subjectivist classroom, activities should serve as “affective multipliers of learning” (Bastick, 1999, p. 2). According to Bastick (1999) the methods used should be geared to trigger *social reactions* similar to what students experience out of school, such as: recognition, shared experience, role identity, in-group bonding and out-group competition. Simultaneously, students should feel *empowered* to explore for themselves and gain confidence in reaching the right conclusions for themselves as they master concepts. Gresalfi (2009) spoke of doing more than meeting the social, motivational and

affective needs of students, but making those influences central to what students do in the mathematics classroom. As found in a case study conducted by Williams and Ivey (2001), “Bryan” attributed his disengagement to not being able to express himself because mathematics has only one answer. Mathematics activities therefore should be more than just finding the answer; they need to be so engrossing that students are more focused on “doing mathematics” than merely “learning [how to do] mathematics” (Van de Walle, Karp, & Bay-Williams, 2016).

For students to feel empowered, they need to be able to make decisions with regard to their learning. As Bastick (1999) demonstrated, social reactions can be triggered by empowering students through the incorporation of three techniques: (a) the *emotional anchor* - giving students open-ended, relevant problems with multiple paths to the solution; (b) the *motivator* – a reason that they can own and make them want to do the activity; and (c) the *cognitive direction* – sufficient information to let them choose the method they wish to go. By providing appropriate guidance, students can be taught to identify paths that are more likely to work and those that are less likely to work. Thus, they learn to troubleshoot for themselves while gaining confidence in their mathematical ability.

For example, in a Grade 7 class in a rural secondary school, Bastick (1999) turned a rote learning lesson about parts of a circle into a set of tasks that exercised the students in three ways: the emotional anchor, the motivator and the cognitive direction. The emotional anchor sought to engage the students, the motivator was meant to make the topic relatable, and the cognitive direction aimed to help the students identify and reinforce concepts. The first task was a group effort to identify unique names for their

teams (the emotional anchor). Each group had to use a part of a circle as the team name (the motivator). For those groups who had difficulty coming up with names, other groups chimed in to either suggest names similar to parts of a circle or give a reason why a name was considered a duplicate (the cognitive direction). Students who needed assistance were called on first so they immediately experienced success by being able to choose more common names. Those answering later felt empowered as they assisted other students in confirming their names. Team members therefore bonded over having an identity they chose together and were ready to move on to the next task as a group.

The next task was to emulate the circle the teacher had drawn on the board (emotional anchor) with each team member drawing a part of the circle (motivator). To achieve this, students had to work together to recognize the idea of constant curvature needed for a perfect circle and determine which team member's contribution did not match and why (cognitive direction). It was up to the children to determine where in the classroom their circle was drawn (on the wall, the floor, the door, or elsewhere), and, most importantly, negotiate which finished product most closely matched what the teacher had done. At the end of the lesson students were laughing over an enjoyable process, yet had identified many concepts related to circles in the process. For example, students had to identify ways of determining which drawing had the better curvature to be considered a better match for the teacher's circle.

Empowerment for Gorrell (1992) is exemplified by the personal meaning that students derive from learning. On the basis of the learner-centered psychological principles espoused by APA (1997), Gorrell (1992) identifies several types of personal meaning:

1. Increased sense of relation of new knowledge to personal events in the learner's life ("I experienced this").
2. Increased sense of self as learner ("I can learn this kind of material").
3. Increased sense of efficacy related to the capability to use knowledge ("I can use this knowledge effectively").
4. Increased curiosity and sense of commitment to extend the learning ("I want to know more").
5. Increased sense of participation in knowledge generation ("I helped create this result").
6. Increased sense of deep understanding ("Learning this helps me understand something else"). (p. 23).

Attainment of these types of personal meaning is what Ma (2006) found to be a good predictor of whether or not students went on to more advanced mathematics course work. Using data from the Longitudinal Study of American Youth (LSAY, 2000), Ma (2006) sought to identify affective factors that had an impact on mathematics achievement. The LSAY followed the lives of a group of seventh graders from fifty public schools in the US, for the next seven years.

Data collected in the LSAY (2000) included student scores on mathematics and science achievement tests and attitudinal and self-report questionnaires; parent interviews; teacher reports; and, school principal questionnaires. Of all the factors isolated (mathematics anxiety, parents' education, SES, and so on), the rate of change in attitude towards mathematics turned out to be the most important factor in determining what advanced mathematics course the students took. For example, students who showed a positive rate of change in attitude towards mathematics were 4.7 times more likely to take at least a precalculus course. Those students who saw the relevance and application of the lower mathematics concepts were the ones who showed higher positive rates of change in attitude and hence were more likely to pursue the higher courses.

The NCTM (2000) approaches the affective/cognitive balance with the use of the five process standards: (a) problem solving; (b) reasoning and proof; (c) communication; (d) connections; and (e) representation. The emotional anchor is provided by using problems that are contextual and relevant. Contextual problems show how the concepts are being used while relevancy is provided by using scenarios to which the students can relate. Cognitive direction can be arranged through the interactive, exploratory activities that require reasoning and proof. Communication provides the means for students to negotiate and identify with each other. As students see how what they are learning plays out in the real world, they are able to establish connections with other subject areas. Finally, their individual expression is achieved in the ways they represent what they are learning. A successful subjectivist pedagogy therefore needs to provide the social interactions and contextual content that will trigger these types of personal meaning as strategies are put into play.

Strategies of a Subjectivist Pedagogy

A subjectivist pedagogy, by definition, has to take into consideration the needs and characteristics of the learners in order to motivate and engage them. Strategies recommended by the National Mathematics Advisory Panel (2008) include:

- Use of cooperative learning groups and structured peer-to-peer learning activities (p. 46)
- Use of formative assessments (p. 47)
- Use of “real-world” contexts (p. 50)
- Addressing social, affective and motivational factors (p. 32)
- Providing social and intellectual support for students and teachers (p. 32).

Through case studies and fill-in-the-blank style questionnaires, research has identified similar strategies that are making a difference. At the top of the list are cooperative

learning, personalizing contexts, and exploration (e.g., Benn, 2009; Grant, 2011; Gresalfi, 2009; Irvin, 2008; Orhun, 2013; Malinen, 1971).

Cooperative learning. Cooperative learning is derived from the principles of social constructivism in that participants learn from each other (Liu & Chen, 2010). However, as each group member is required to participate, each group member is also held accountable for individual learning (Applefield et al., 2001). Multiple intelligences can also be intentionally activated as students take part in cooperative learning (Isik & Tarim, 2009). By working with activities that appeal to each intelligence, students who are more fluent in that intelligent area will be encouraged to take the lead in coming up with solutions. So first, their emotions are stimulated to look at the problem, then attention is maintained as they explain it to others, thereby satisfying the social intelligence need to belong.

On the basis of the principles of social constructivism, Cunigan-Wells (2014) analyzed how teachers were using cooperative learning in middle schools with low reading achievement levels. Since reading is involved in problem-solving, it is beneficial to consider students' reading levels and how they may be affecting mathematics scores. The study was setup to employ certain features of cooperative learning: "(a) group participation, (b) shared responsibility, (c) quality of interaction, (d) member roles, (e) team resolutions, and (f) individual accountability" (p. 106). Students had to work on problems where they (a) applied concepts to solve new situations; (b) made inferences and found evidence to support the inferences; and (c) used multiple representations and strategies (p. 105).

The way the teachers implemented the features varied depending on the time allotted for each lesson but they were able to implement a cooperative teaching model that took the students beyond completing worksheets into critical thinking and problem solving. Some used lesson content from social studies, some from science and some from mathematics. For example, in the mathematics class, students had to classify which equations were always true, sometimes true or never true. Then they had to paste the equation into the correct column. By adding this physical involvement to the lesson, off-topic interruptions were kept to a minimum. In all classes, by designing assignments that required critical thinking, students had to employ such in order to reach group consensus. Overall, students responded positively and appeared to be more engaged in their work.

Mourning (2014) went further to look at how achievement changed as the result of using cooperative learning groups following the Kagan Cooperative Learning Model (Kagan, 2015). The Kagan Cooperative Learning Model consists of an entire curriculum that uses cooperative learning to target economically disadvantaged students. It includes details about how and when to form teams, how to manage the classroom and step-by-step guides for structuring the lesson. The Kagan Publishing and Professional Development group also provides actual games and activities that can be used in cooperative learning exercises to make learning more engaging. As with social constructivism, Kagan emphasizes the need for positive interdependence, but goes beyond to stress the need for individual accountability, equal participation and simultaneous interaction.

Following the Kagan Cooperative Learning Model, (a) specific group activities were planned to encourage student-student interaction; (b) teachers monitored group

conversations and progress; (c) teachers assessed group progress constantly; and, (d) group sharing and team building activities were encouraged. All students were assessed over two years using the North Carolina End of Grade (NCEOG) achievement scores in mathematics. Those who were involved in the sections using the Kagan Cooperative Learning Model showed a greater gain in average achievement scores. Although the gain scores for both groups were significant, the treatment group ended up with a higher average score on the NCEOG. The treatment group's NCEOG score was also found to be significantly higher than that of the control group.

In Irvin's (2008) study at a suburban high school in Brisbane, social constructivism was practiced in the mathematics classroom with the use of group discussions and games, along with other strategies. The teachers and researcher found that the speaking and hearing involved in the discussion created a "social practice or a community" (p. 27). The games helped to build social interaction while also forcing dialogue. Requiring students to create games gave them the opportunity to be creative (insert themselves in the activities) while applying the mathematics they were learning. In particular, teachers themselves became a community of learners as they met each week to review the project. From sharing notes and the reactions of the students, they saw the need for this level of interaction to be planned and not just left to chance.

Personalized contexts. Information needs to be personal and relevant if it is to appeal to the affective side of students (Bastick, 1999). Students need to be able to connect with the problems they are solving and the problems need to be stated in terms to which the students can relate. Being able to relate to the problem is what appeals to the emotions so that the focus of the brain shifts to solving the problem (D'Angelo, 1998).

The more personal, the longer the emotions can be engaged, thereby sustaining focus for learning (Connell, 2009).

The study conducted by Williams and Ivey (2001), in an eighth grade algebra class, analyzed the case of “Bryan” who was doing well in algebra but was disengaged for most of the school year. On the two occasions when Bryan appeared animated the group was asked to justify their solutions, and the teacher used mathematics to perform magic tricks. In the first instance, Bryan was able to express himself in his own words about what he was doing. In the other instance, he saw where the teacher could use the mathematics to achieve something that was related to the teacher’s hobbies. Therefore, by using problems to which students can relate and that can provide multiple solutions students will feel a part of the activities and will have to justify their solutions. As students think of how to justify their solution, they will learn how to determine the correctness of a solution without having to wait for the teacher’s sanction or trying to match the answer at the back of the book.

At schools in Guyana, these and other strategies have been put to the test. Benn (2010) explored the use of constructivist methods versus traditional didactic methods in teaching the multiplication of fractions. Although the topic was not algebra-related, the results of Benn’s (2010) study would indicate whether or not students are even open to constructivist methods in mathematics. Constructivist methods included question / answer, observation, discussions, drawing, prompts for alternative ways of working problems and practice. Traditional methods included presenting rules, explaining the rules, allowing students to write the answers on the board, providing practice time, and then reviewing the rules. Two groups were formed of 40 Grade 6 students from a leading

primary school. Both groups were pre- and post-tested using a mix of knowledge-based, comprehension and application questions.

The treatment group showed gains of over 52% while the control group showed gains of 48%. The difference was found to be significant at $p < 0.05$. However, though there was some interaction, activities were more focused on experimenting with the rules instead of having students derive them. Thus students like “Bryan” may have still not been motivated sufficiently since there was not much room for personal expression. Yes, they could express themselves differently by drawing or discussing, but they were drawing an already accomplished fact instead of having the opportunity to “discover” something for themselves.

Exploration. Benn (2009) looked instead at what was considered effective teaching strategies that included (a) encouraging cooperative learning; (b) allowing students to manipulate concrete objects; (c) using different stimuli such as music, role play and interacting with the environment; (d) varying teacher strategy according to student experience; (e) using formative assessments; and, (f) encouraging discussions.

Teachers had to attend a workshop to be trained on using the various methods (Benn, 2009). Participants consisted of seven Grade 7 mathematics teachers working with 177 students from three secondary schools. The focus of the study was on observing teacher use of the strategies and students’ reactions to the various teaching strategies in mathematics classes. Although teachers used cooperative learning strategies only about 10% of the time, 65% of them ranked it as the most effective. Practice exercises were used about 30% of the time and 20% of them ranked it as most effective. The lecture

method was used about 40% of the time but 50% of the teachers ranked it as being least effective.

Overall, 90% of the respondents felt the curriculum was more learner-centered. With regard to the student performance, the algebra post-test scores indicated 48% of the students at or below 50%. However, the overall average on the post-test at 54.7% was double that of the pre-test at 25.2%. In the absence of a control group, it is not clear that using these strategies is any better than the traditional lecture method. However, on the basis of observation of students' participation in class, it was clear that the students enjoyed themselves more and were able to learn some of the concepts. These results are important in that, to date, students are still dependent on explanations from the teacher and the use of more interactive teaching methods is still quite novel (Pestano-Moonsammy, 2014).

Misconceptions in Algebra

As part of catering to the affective needs of students, care must also be taken to address misconceptions that students develop as they try to carryover their understandings of arithmetic to algebra. In a review of research from 1976 to 2008, Welder (2012) identifies four areas in which students have difficulty making the leap to algebra: the usage of (a) brackets, (b) the equal sign, (c) operational symbols, and (d) letters.

When students first encounter brackets in arithmetic, they are presented with a static image in that the expression within the brackets is to be evaluated first (Linchevski, 1995). In algebra, brackets (or parentheses) can move around to rearrange how an expression is evaluated or even to be used more in a multiplicative fashion as terms are

distributed. Students should therefore be encouraged to look at equivalent expressions that use brackets (or parentheses). They should also evaluate the same expressions with and without the parentheses so that they can see how the value changes and observe the need for the parentheses.

The equal sign is even more commonly misused as students first learn that the answer follows the equal sign (Welder, 2012). In a study done with sixth to eighth graders, Knuth and colleagues (2008) found that over 48% of the students in seventh and eighth grade considered the equal sign an indication to perform the calculation on the left side and only 41% thought it indicated an equivalent relationship. Those who recognized the equal sign as an equivalence indicator went on to correctly solve equations that had more than one term on the right hand side. Those who did not recognize the equal sign as an equivalence indicator could not even correctly identify missing terms.

Viewing the equal sign as an action instead of a relationship leads to students using the equal sign incorrectly between steps of a solution ending up with something like: $4x - 7 = 32 = 4x = 32 + 7$. Other students, given an equation like $2 + x = 5 + 3$, have to split it into two equations such as $5 + 3 = 8$ and $2 + x = 8$ (Knuth et al., 2008). To reinforce a meaning of equality as students encounter the equal sign, care should be taken to use words such as equivalent instead of “equal to” (Knuth et al., 2008; Van de Walle, Karp, & Bay-Williams, 2016); present an image of a balance scale as a representation of an equation (Ketterlin, Jungjohann, Chard, & Baker, 2007); and present problems with multi-term expressions on both sides of the equal sign (Welder, 2012).

The misconception with the equal sign is carried over to other operational symbols. For example, the plus sign is usually associated with adding two terms.

However, when the terms are a whole number and a fraction, the plus sign is understood: “ $3 + \frac{1}{2}$ ” can be written as “ $3 \frac{1}{2}$ ”. Going to algebra, students likewise consider that “ $2 + a$ ” can be written as “ $2a$ ” (Mitchell, 2006) or may think that “ $4a$ ” means “ $4 + a$ ” (Welder, 2012). As expressions include more variables, students may combine coefficients then just put the variables together. For example, in interviews with her students, Mitchell (2006) noted students combining the coefficient numbers (ignoring the variables) in $3h + 4j - 2h$ to get 5 then just putting the variables together (alphabetically) to get $5hj$ (p. 7). Ignoring the variables shows students’ misunderstanding of how the variables are being used and the meanings associated with them. Here again, language is important in talking about these expressions. As recommended by Van de Walle and colleagues (2016), elementary school students should be presented with alternate ways of representing totals such as using 12 or “ $7 + 5$ ” so they get used to seeing expressions as quantities.

Students taking part in the present study will have already been introduced to variables and algebraic expressions so more focus will be placed on providing scenarios that will help students to identify and avoid misconceptions with brackets (or parentheses) and the equal sign. Understanding these elements will certainly be key to doing well on the national assessments.

Algebraic Understanding in Guyana

Being comfortable with the equal sign and other algebraic symbols goes beyond procedural understanding to more of a relational understanding (Byrd, McNeil, Chesney, & Matthews, 2015). Without a relational understanding of the equal sign students may place more focus on the numbers and proceed to “find the result” instead of solving the

equation. For example, when presented with a problem such as: $4 + 7 = 3 + \underline{\hspace{1cm}}$, students may focus more on the plus signs and numbers and seek to evaluate the sum of 4 and 7 to fill in the blank instead of recognizing the part the equal sign plays in relation to the 3.

The need for such an understanding is now being encouraged in the schools in Guyana. Demonstrating algebraic understanding is now expected to go beyond simply picking the correct answer in response to a multiple-choice question. Not only does it entail being able to reproduce the correct mathematical steps to arrive at an answer, but students also need to be able to see that there is more than “ ‘one right way’ of doing things” (Carrington, 1993, p. 39).

Move to Relational Algebraic Understanding

Textbooks of earlier years consisted of multiple examples with little explanation of the concepts, as shown in Figure 1.

Figure 1. Page of textbook from 1991 (Layne et al., 1991).

Nowadays the textbooks are a little more informative with more descriptions of the concepts, color and diagrams of what is taking place as shown in Figure 2 (Toolsie, 2007).

Procedure

To divide an algebraic term by an algebraic term:

- Cancel common factors in the coefficients, if any exist.
- For common bases, subtract the smaller index from the larger index.
- Simplify to obtain a single algebraic term.

or

- If the divisor is an algebraic fraction, then invert the algebraic fraction and multiply instead of divide.

Exercise 9i

Simplify each of the following algebraic expressions:

- (a) $4x^2y \div 2xy^3$ (b) $10p^2q^3 \div 4pq$
- (a) $15a^3b \div 5ab^4$ (b) $12m^2n^3 \div 3mn^5$
- (a) $4x^3y^5 \div 8xy^3$ (b) $9p^3q^2 \div 6p^2q^3$
- (a) $6a^2b^4 \div 3a^3b^2$ (b) $4m^3n^2 \div 8mn^6$
- (a) $10x^5y^4 \div 4x^3y$ (b) $6p^3q^2 \div 2p^2q$

Simplify each of the following expressions:

- (a) $\frac{1}{2}x^2y \div \frac{3}{2}x^4y^2$ (b) $\frac{3}{4}p^3q \div \frac{3}{2}pq^2$
- (a) $\frac{2}{3}a^2b^3 \div \frac{8}{3}a^2b$ (b) $\frac{3}{5}m^4n^2 \div \frac{6}{5}m^2n^3$
- (a) $\frac{x^3y}{3z^2} \div \frac{xy^4}{6z}$ (b) $\frac{p^3q^4}{4r^3} \div \frac{pq^2}{8r}$

BRACKETS: THE DISTRIBUTIVE LAW

In order to remove brackets, we use the *distributive law*. Each term within the brackets is multiplied by the term outside the brackets. This process is called *expansion*.

Thus,

$$a(b + c) = ab + ac \text{ and } a(b - c) = ab - ac.$$

Remove the brackets in each of the following algebraic expressions and simplify if possible.

(a) $5(x + 3)$

(c) $3x + 4(x - y)$

(b) $-2x(3x - 4)$

(d) $4x - 3x(-5x + 2y)$

(a) $5(x + 3) = 5 \times (x + 3)$
 $= 5 \times x + 5 \times 3$
 $= 5x + 15$

(b) $-2x(3x - 4) = -2x \times (3x - 4)$
 $= -2x \times 3x - 2x \times (-4)$
 $= -6x^2 + 8x$

(c) $3x + 4(x - y) = 3x + 4 \times (x - y)$
 $= 3x + 4 \times x + 4 \times (-y)$
 $= 3x + 4x - 4y$

Figure 2. Page of textbook in use in 2015 (Toolsie, 2007).

Additionally, both the Ministry of Education and the examination board suggest the use of a wider variety of activities (Ministry of Education, Guyana, 2013d), as shown in Figures 3 and 4, to encourage students to extend their knowledge and apply what they have learned.

Ministry of Education Secondary Sector Mathematics Grade 8 Christmas Termly Scheme	
Content	Activities
<p>The commutative law. Examples: $8 + 12 = 12 + 8$ $8 - 12 \neq 12 - 8$</p> <p>The order in which we add or multiply numbers does not matter. The result is always the same.</p> <p>The operations of addition and multiplication satisfy the commutative law.</p>	<p>Discussion of the commutative law with examples. Stating the commutative law.</p>
<p>The associative law. Examples: $(8 + 12) + 2 = 8 + (12 + 2)$ $(8 - 12) - 2 \neq 8 - (12 - 2)$</p> <p>The order in which we add or multiply numbers in groups of two does not affect their sum or product. The operations of addition and multiplication satisfy the associative law.</p>	<p>Discussion of the associative law with examples. Stating the associative law.</p>
<p>The distributive law. Examples: $(4 - 5) + (4 - 3) = 4 \times (-5 + -3) = 4(-5 + -3)$ $(4 \times 5) - (4 \times 3) = 4 \times (5 - 3) = 4(5 - 3)$</p> <p>Multiplication distributes over addition and subtraction.</p>	<p>Discussion of the distributive law with examples. Stating the distributive law.</p> <p>Discussing and identifying social situations in which mathematical laws can be observed.</p>

Figure 3. Variety of activities for use in the classroom
(Ministry of Education, Guyana, 2013d).

Suggested Teaching and Learning Activities

To facilitate students' attainment of the objectives of this Section, teachers are advised to engage students in the teaching and learning activities listed below.

1. Encourage the use of:
 - (a) calculators;
 - (b) games and quizzes;
 - (c) appropriate software (for example, equation solving apps);
 - (d) examples of algebraic problems drawn from real-life situations; and,
 - (e) online demonstrative videos.
2. Explore the link between algebra and other disciplines, for example:
 - (a) Music: the use of music symbols;
 - (b) Sciences and Nature: rearranging scientific formulae;
 - (c) Architecture: determine the size or number of tiles/windows/doors of a floor or wall; and,
 - (d) Business Studies: solving equations to determine profit/loss, demand and supply.

CXC 05/G/SYLL16

28

ALGEBRA (cont'd)

3. Introduce students to symbolic representation using examples drawn from everyday life such as safety symbols, road signs and other familiar informational and warning signs.
4. Promote appropriate use of variables. For example, differentiate between 5m as an abbreviation for 5 metres and 5m, where m represents the number of mangoes bought.
5. Explore the concept of equality through the use of:
 - (a) Pan Balance activities with numbers ($8 + 4 = x - 2$) and shapes; and,
 - (b) Hands-on Algebra.
6. Use manipulatives such as integer chips, algebra tiles and other appropriate materials to develop the understanding of:
 - (a) operations with integers;
 - (b) simplifying algebraic expressions (adding/subtracting like terms);
 - (c) multiplying binomials of power 1;
 - (d) solving linear equations with one unknown; and
 - (e) rearranging an equation/formula.
7. Conduct labs to assist students in the efficient use of calculators. For example: to explore the order of operations, to evaluate expressions with exponents and roots.

Figure 4. Suggested classroom activities (CXC, 2015).

On the CSEC Examination students are reminded that they will receive full marks (the highest possible score) only if full working or explanation is included in the answer. Students are required to answer questions like those shown in Figure 5. Certain questions allow for the use of a calculator, but all students can answer even if they have not been practicing with calculators in class.

SECTION I
Answer ALL the questions in this section.
ALL working must be clearly shown.

1. (a) Using a calculator, or otherwise, determine the exact value of

(i) $(1.5)^2 + (2.1)^2$

(ii) $\frac{4.8 + 6.9}{1.5 \times 0.2}$

(iii) $\frac{3\frac{1}{3} - 2\frac{3}{4}}{2\frac{1}{5}}$ (7 marks)

(b) (i) Write the answer in Part (a) (i) correct to one significant figure.
(ii) Write your answer in Part (a) (ii) in standard form. (2 marks)

(c) Give the three (3) mathematical laws. (3 marks)

Total 12 marks

2. (a) Simplify

(i) $3m - 2(m + 1)$ (2 marks)

(ii) $\frac{3}{y} - \frac{2}{y-2}$ (3 marks)

(b) Solve the equation

$3(x - 8) = 2x$ (3 marks)

(c) Expand and Simplify

$\frac{2}{5}(3x - 7)(5x + 10)$ (3 marks)

Total 11 marks

Figure 5. Mock CSEC mathematics exam.

Then they can select which of the more advanced questions they will answer. Note how each question has multiple parts as shown in Figure 6.

SECTION II

Answer ANY TWO questions in this section.

8. (a) Given that $M = \begin{pmatrix} 2 & 5 \\ 7 & 15 \end{pmatrix}$

- (i) Show that M is a non-singular matrix. (2 marks)
- (ii) Write down the inverse of M . (3 marks)
- (iii) Write down the 2x2 matrix which is equal to the product MM^{-1} . (1 mark)
- (iv) Pre-multiply both sides of the following matrix equation by M^{-1} .

$$\begin{pmatrix} 2 & 5 \\ 7 & 15 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} -3 \\ 17 \end{pmatrix}$$
Hence solve for x and y . (4 marks)

(b) A bag contains 2 white marbles and 3 blue marbles.

- (i) A marble is selected at random from the bag. Calculate the probability that the marble is white. (2 marks)
- (ii) If the white marble is NOT replaced in the bag, calculate the probability that the second marble selected from the bag will be blue. (3 marks)

Total 15 marks

Figure 6. Mock CSEC mathematics exam, Section II.

In developing full understanding, teaching strategies not only need to help students get used to seeing this type of problem layout, but need to elicit the use of appropriate mathematical language in solving each problem. Care should be taken with the language used in activities, and example problems should be appropriately varied to help students understand of the use of brackets (or parentheses), the equal sign and other algebraic symbols.

CHAPTER III

III. METHODOLOGY

This chapter opens with a review of the purpose of the study and the research questions and hypotheses. Next, details about the study are presented including the research design, population and sampling, variables and instrumentation, and the data analysis that was conducted.

Purpose of the Study

The purpose of the present study was to investigate how the use of subjectivist instructional strategies (SIS) in teaching multiple sections of an eighth grade algebra class in Guyana related to achievement in algebra and attitude changes towards mathematics. By combining the techniques espoused by Bastick (1999) with the strategies promoted by the National Mathematics Advisory Panel (NMAP, 2008) it was hoped that students would be able to derive the personal meanings identified by Gorrell (1992). Strategies included cooperative learning groups and guided exploratory activities to which students could relate. Care was taken to design activities that would clarify misconceptions in algebra.

Research Questions and Hypotheses

Two research questions guided the present study: (a) What is the relation between the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana and the students' attitudes towards mathematics? and (b) What is the relation between the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana and the students' achievement in algebra? These relationships were investigated while controlling for sex,

challenges, and prior mathematics scores. To explore these questions, three hypotheses were tested:

H₁: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment attitude scores towards mathematics, when controlling for sex, challenges, and pre-treatment attitude scores.

H₂: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment achievement in algebra when controlling for sex, challenges, and prior mathematics achievement scores.

H₃: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment achievement in algebra over and above what is predicted by a difference in attitude scores towards mathematics when controlling for sex, challenges, and prior mathematics achievement scores.

Research Design

A combination of subjectivist interactive strategies was used by the researcher to teach eighth grade algebra to students at a high school in Georgetown, Guyana. In the present study, the predictor variable was manipulated by randomly selecting which sections of the Grade 8 algebra class served as the treatment group. Two other sections became the control group. A quasi-experimental design was used as participants were not being randomly selected (Tabachnick & Fidell, 2007). The criterion variables: posttreatment attitude towards mathematics and algebra course score, used continuous

scores while the predictor variable, teaching style, was categorical. Analysis with General Linear Models (GLM, McNeil, Newman & Kelly, 1996) was conducted using the Statistical Package for the Social Sciences (SPSS) and included determining the variance accounted for in predicting final algebra achievement scores and attitudes towards mathematics.

Statistical Parameter Settings

An acceptable probability of Type I error as 0.05 was used in the present study (Coffey, 2010; McNeil et al., 1996), though a review of the literature shows values between 0.01 and 0.10 in use (e.g., Cartledge & Sasser, 1981; Hemmings, Grootenboer, & Kay, 2011; Taylor, 2008; Yang, Cho, Mathew, & Worth, 2011). A Type I error can occur when a null hypothesis is incorrectly rejected leading to the erroneous conclusion that what the sample portrayed did not occur purely by chance and would probably show similar results in the population. In the present study, had a Type I error occurred the idea of using different teaching strategies may have been reinforced. As a result, the Ministry of Education in Guyana may have revisited requiring that teachers use different teaching strategies leading to a wide scale retraining of teachers. Had a Type II error occurred, where the null hypothesis was false yet was not rejected, an opportunity may have been lost to provide some benefit to the students since these strategies have their basis in past success.

A test with high power minimizes the probability of making a Type II error. However, as the probability of a Type II error decreases, the probability of a Type I error will increase. Therefore, the present study sought to maximize the power of the test so a minimum power level of 0.80 was acceptable.

In considering relations between attitude and achievement, research shows effect sizes ranging from 0.00 to 0.52 (Ma, 1995). However, as acceptable effect sizes in educational research tend to be lower (Murphy & Myers, 1998) a minimum effect size of 0.25 was deemed to be acceptable for the present study.

Source of Data

Setting

Participants for the present study were students in the eighth grade level from Jac High, a pseudonym for a high school, in Georgetown, Guyana. In Guyana, students enter secondary school at age 10 or 11, starting at Grade 7. Which school students attend is determined by their score on the NGSA. Top scorers are assigned to one of the five leading schools which support education up to the first year of college (Ministry of Education, Guyana, 2013b). The next layer of scorers are assigned to List A to List C high schools in accordance with cutoffs determined by pass rates on the NGSA. Those not scoring high enough on the NGSA for entry into even a List C school will be assigned to the secondary department of a primary school that supports education up to the ninth grade. Upon completing ninth grade, the students can once again take a test for entrance into one of the listed high schools. Listed schools provide education up to Grade 11 at which time students can take the school-leaving Caribbean Secondary Education Certificate (CSEC) examination (Ernest, 1984) administered by the Caribbean Examinations Council (CXC).

Results from the CSEC examination are used to determine the type of job for which they qualify, or for access to the “6th Form” (Ministry of Education, Guyana, 2013b) of a leading high school where they cover material that is equivalent to the first

year of college. Passing five subjects including Mathematics and English at the CSEC is required if students wish to find professional jobs such as working in a bank or government office. Without Mathematics or English, students can hope for an apprenticeship or can go on to a trade school.

Jac High school started out being privately owned and has always accepted children of both sexes. In 1976 all schools were nationalized by the government, and students no longer had to pay to attend nursery school through university (Education Encyclopedia, 2015). Jac High is located within the capital city, Georgetown, and is accessible by minibus or taxi. As is the case with other schools in the vicinity, Jac High has access to private school bus service. It is possible that some students may walk to school but most students ride the minibus. Jac High has an alumni association that is actively involved in the operation and funding of the school.

Schools in Guyana require that students wear a uniform reflecting the school's colors, and a badge that identifies the school. Eighth grade boys at Jac High wear short pants, matching belt and black socks. Shirts have to be tucked in unless they have an exception such as for religious reasons. Girls wear a tunic, matching belt and white socks. Whenever students are attending academic functions on school premises or on behalf of the school, they need to be in uniform.

Jac High has a canteen onsite from which students can purchase lunch and other snacks. Classrooms contain a two-person chair/desk combination for each pair of students, a teacher's desk, and a chalk board or whiteboard. Teachers are free to use a laptop, posters or any other manipulatives they deem necessary. In some rooms, an overhead projector may be available. A computer lab is available which the students use

periodically for completing projects for their courses or for the CSEC examination.

Priority access to the computer labs is given to upper class students, such as the Sixth Formers and those preparing for national assessments.

According to the Secondary School List published by the Ministry of Education in Guyana (Ministry of Education, Guyana, 2017), Jac High was considered a “List A” school on the basis of its pass rate at the CSEC and the size of its student body at the time of the present study. Students involved in the present study would have taken the NGSA in 2014.

Population

Students are placed into seventh grade at each school according to their score on the NGSA. At the time of the present study, students scoring over 92% on the NGSA were assigned to the leading five schools in the country (Ministry of Education, Guyana, Examinations Division, 2014). Those scoring between 77% and 92% were sent to List A schools such as Jac High. Once students completed the annual end-of-school-year examination, they were promoted to the eighth grade. For the purposes of the present study, the population comprises the eighth graders of Jac High.

Jac High had six sections in the eighth grade at the time of the present study, each with about 30 to 35 students. Many of the students were considered to be of lower SES and the school had various voucher and breakfast programs for them. Since many regions within Guyana are not easily accessible, students are sent to live in Georgetown so that they can attend a better school, be it a leading school or Jac High. As such, some students lived with extended family or friends, or commuted for several hours each day. Even those living closer to the school needed to take up to 3 different modes of

transportation such as walking from home out to the main road where they can catch a minibus. Those coming from the East Bank had to change buses at Stabroek Market in downtown Georgetown. Once dropped off by the next bus, they then had to walk in to get to the school.

In the eighth grade, students took classes in agriculture, information technology, English, mathematics, arts (including dance and drama), technical drawing, mechanical technology, electrical technology, reading and social studies (Ministry of Education, 2013d). Mathematics classes were supposed to meet for a double period of 70 minutes three times per week for a total of 210 minutes. However, for the first period in the morning or the first period after lunch, up to 30 minutes were usually taken up with getting back to class after assembly, taking attendance, and cleaning the classroom.

Teacher Background

The teacher for the control group was a retired headmistress with over 40 years of experience at the primary, secondary and tertiary school levels. Her most recent assignment was as head teacher for a rural secondary school. She is a trained Class 1 teacher and holds a Bachelor's degree in Education Mathematics and a diploma in Public Administration. She has been involved in the setting and grading of national mathematics assessments. Currently, she continues to hold lessons sessions where she prepares students to take the national assessments.

The researcher started her career as a Teacher at a high school in Guyana. There, she was responsible for teaching mathematics (and other subjects) to seventh, eighth and ninth grade students. Since then, she migrated to the US where she has lived for over 39 years. She holds degrees in mathematics and computer science and is completing the

doctorate in curriculum and instruction. Over the years, she has taught at the tertiary level and done extensive corporate training in the traditional and online venues. Most recently, she has been working with primary and secondary school teachers in the US and in Guyana on using more student-centered, interactive teaching methods. Some of these methods include the subjectivist instructional techniques used in the present study.

Power Analysis and Sample Size

According to Cohen's power analysis tables (as cited in McNeil, Newman, & Kelly, 1996), to achieve a power of 0.80 to detect a minimum effect size of 0.25 with alpha of 0.05 at least 95 students needed to be included in the study of these hypotheses. However, allowing for 15% attrition (Stillson & Alsup, 2003), at least 110 students needed to be available for the study. Four sections were needed, of which two were the control group and two sections were the treatment group.

Procedures

This project was implemented at the beginning of the school year when students started Grade 8. A letter was sent home to parents to let them know about the project and to request their permission for the students to take part. Meetings were held with the eighth grade head of department for the researcher to get acquainted with him and to finalize the class schedules. Two Grade 8 sections which turned out to not have a mathematics teacher were assigned to the researcher as the treatment group. Two other sections were assigned to a local visiting teacher to serve as the control group. The control group sections also had a regular teacher assigned who was on hand to assist the visiting teacher with maintaining discipline. The visiting teacher was a retired

headmistress who was still involved in providing extra lessons for students across all grade levels.

Once permission forms were collected from parents, students were asked to sign assent forms. The MVI was then administered to determine the student pre-treatment attitude towards mathematics scores. The study lasted for the entire term. With holidays, rainouts, sports and school closures, the teaching time was about 10 weeks during which two tests and one comprehensive examination were administered. At the end of the term, students were asked to provide demographic data such as their sex; some information about their study habits; and, information about the challenges they faced. They were also asked to take the MVI once more. Topics covered included mathematical laws; addition, subtraction, multiplication and division of directed numbers; algebraic expressions; and, binary operations. Once scores were tallied after the comprehensive examination, analysis was conducted on the achievement and attitude scores.

Treatment Group Process

In the present study, the major change in how students have been taught over the years was that students in the treatment group were guided in exploring concepts for themselves. The intention was for them to use a logical, deductive approach to arrive at the procedures necessary to solve the problem instead of just memorizing a set of steps. As demonstrated by Imrit (1978) and recommended by Bastick (2000), formal definitions were delayed until after students were able to experiment with scenarios to which they could relate. In this way, they were empowered to make decisions (Benn, 2010; Orhun, 2013) and to insert themselves into what they were doing, as “Bryan” desired (Williams & Ivey, 2001). Working in cooperative learning groups (NMAP, 2008) was meant to

provide both the social reaction and the emotional anchor needed for students to experience personal meaning (Bastick, 2000; Gorrell, 1992).

For convenience, groups were sometimes formed according to how students were seated in the classroom. Other times, students were randomly assigned to groups. The cooperative learning aspect was encouraged by reminding group members to discuss “how” to work a problem instead of just giving out answers to each other. Each group member had to be ready to exhibit understanding of the concepts and be prepared to justify the group’s responses. Each one therefore had the responsibility to ask questions until concepts were fully understood, or to share knowledge gained with each other.

At each class session, there were two to four teaching assistants to work with the various groups. The assistants were students who had recently graduated from high school or were attending college. Their function was to help keep students on-task and to provide small-group tutoring. Owing to the high noise level, it was easier to discuss concepts in the small groups and the students relished the more personal attention. In this way, an attempt was made to keep students more focused on reasoning through concepts.

Each lesson began by activating prior knowledge either with the help of an activity or a simple question and answer session. An activity followed that introduced the day’s theme and set the frame of reference for the real-world problems to be solved. Working in groups, students sometimes needed to figure out answers to a series of questions that led to the development of the day’s concept. As they developed inferences they were sometimes able to use manipulatives to analyze them, in hopes of building critical thinking skills (Grainger, 1993).

For example, to explore the concept of positive and negative numbers, we talked about land areas that were considered to be above and below sea level, using the graphics and questions shown in Figure 7.

<p>Hotel bungalows in Bora Bora, French Polynesia. They are built using stilts to lift them above sea level.</p>	<p>A man walks along the seawall behind Better Hope, East Coast Demerara as water overtops.</p>
<p>Representing Distance</p> <ul style="list-style-type: none"> How would you represent the distance above sea level? How would you represent the distance below sea level?

Figure 7. Graphics used in discussing positive and negative numbers.

Guyana is below sea level so has a seawall that runs the length of the coastline. At high tide, the ocean water can be seen washing over the wall at some parts. We then talked about different places around the world that were at different elevations and students had to mark where these places would fall on a vertical number line. Following this, we talked about which places were higher or lower and how we can find the distance between the places as shown in Figure 8.

Which is higher? Which is lower?

(Source: <http://www.pbs.org/wgbh/nova/education/earth/hurricanes-new-orleans-threat.html>)

New Orleans is 3.7 m below sea level.

According to Geology.com there are several other areas around the world that are below sea level.

Mark on the picture where you think each of these areas would be located.

- a. → Suriname is 2 m below sea level
- b. → The Fens in the United Kingdom is 4 m below sea level
- c. → Lake Hammarsjön in Sweden is 2.41 m below sea level
- d. → Lake Eyre in Australia is 15 m below sea level
- e. → Guyana is 1 m below sea level

Compare the elevations.

- 1. → Which has the highest elevation?
- 2. → Which has the lowest elevation?
- 3. → Using the greater than ($>$) or lesser than ($<$) sign show how the elevations compare between The Fens and Lake Eyre.
- 4. → If the city of Pandora's Dust is 5 m above sea level, show how its elevation compares with Lake Hammarsjön.
- 5. → Show all elevations on the number line.

¶

Bonus question: -¶

If Mount Villigili in the Maldives is 2 m above sea level, how far is it above Lake Eyre?

Figure 8. Comparing positive and negative numbers.

When considering the concept of adding positive and negative numbers we followed the adventures of Mr. Rabbit. Students could use any animal, fish, bird or whatever object they wanted to draw in their books. Since we did not have access to a projector and to minimize off-task talking, we used the handout shown in Figure 9.

Mr. Rabbit's Travels

Example:
 Mr. Rabbit hops 4 paces East. Show this movement on the number line.
 From this point, he then hops 5 more paces East. Show this movement on the number line.
 Where does he end up?

Write the mathematical sentence. $+4 + 5 = +9$

1. Starting at 0, Mr. Rabbit hops 3 paces East. Show this movement on the number line.
 From this point, he then hops 2 more paces East. Show this movement on the number line.
 Where does he end up?

Write the mathematical sentence.

2. Starting at 0, Mr. Rabbit hops 2 paces West. Show this movement on the number line.
 From this point, he then hops 6 more paces West. Show this movement on the number line.
 Where does he end up?

Write the mathematical sentence.

Figure 9. Adding positive and negative numbers.

First we worked through the example together with students drawing in their books. Then in groups, they worked through the other questions, with teaching assistants giving guidance. Later in the term as we reviewed these topics, students were asked to name situations which could be represented by positive numbers, and those that could be represented by negative numbers. They came up with ideas such as borrowing money, receiving gifts and moving up or to the right (East) as being modeled with positive numbers. For negative numbers, they suggested repaying money, losing money, or moving down or left (West). We discussed thinking about how much money they have

(positive number), how much they owe (negative number), and how much they are left with after repaying (combining positive and negative numbers). In all cases they were asked to derive any pattern they noticed about the results, and to prove that the results were correct.

In exploring concepts of multiplying positive and negative numbers students worked with a weight loss/gain scenario. In thinking about losing 3 pounds per day they needed to think about how the loss of 3 pounds would be represented (as a negative number), then they had to answer questions such as how many pounds were lost in 5 days, and derive the representation of $-3 * 5 = -15$. Alternatively, they needed to answer questions like how much more the person weighed 5 days ago, with a representation of $-3 * -5 = 15$. It was hoped that not only would they be getting practice in creating mathematical expressions, but also be gaining an understanding of the logic behind the rules we take for granted in talking about *negative times negative gives positive*.

Formative assessments entailed students applying what they learned to other scenarios, or developing similar problem sets for their partners to solve (Cunigan-Wells, 2014). Problem results needed to be shown using multiple representations (NCTM, 2000) as students detailed how they arrived at their answers. When time allowed, the class was wrapped up with a whole-class discussion in which a member of a group was called on randomly to describe the group's results. Homework assignments were periodically assigned to provide the necessary practice of what they learned in class and consisted of similar real-life contextual problems to which the students could relate.

Towards the end of the term, as students got into the holiday mode and there were more breaks in regular school days, the noise level precluded having discussions or doing

much talking. Certainly, administrators tried to be more vigilant about keeping students disciplined but the students' focus was not there. So, review was done using a variety of computer games. Students also had the opportunity to meet with the teacher outside of class time to review any material about which they were unsure. In this way, they were able to receive more one-on-one attention.

Control Group Process

The control group was taught using methods that most teachers used. As the teacher reported, her focus was on doing lots of practice work. She completed many exercises with them, having them work on the board individually. Exercises came from mathematics textbooks and practice papers. In her estimation, since they knew that each person would have to go to the board and work, they would go home and do their own little practice to build their confidence. If they worked it wrong, then any other student was called on to correct it on the board. She focused on using the chalk board and encouraging the students to teach their friends after class.

Efforts were all focused on procedural practice of the type of problems that would show up on the assessments – no word problems were incorporated. Homework was assigned at the beginning of the term but not very often towards the end since many students were not submitting it. Instead, more focus was placed on rehearsing material in the classroom and reviewing their notebooks. The assigned class teacher was also on hand to assist with keeping the students on-task.

Observation Process

Each section was observed three times throughout the study. As each section had a morning and afternoon time slot each week, observers visited each section twice in a

week at different times. Each visit lasted approximately 20 minutes and occurred at varying times such as at the beginning, in the middle or at the end of the class. The observers were a male second-year college student and a female executive assistant. They were tasked with filling out the same evaluation shown in Appendix C. Questions on the evaluation covered teaching style, students' attention, problem types being used and relevance of material being discussed. Observers had to pick the best descriptive answer, and could also write in any other notes they wished.

Variables and Instrumentation

The predictor variable to do with the use of subjectivist strategies was treated as a dichotomous variable with 0 representing the control group and 1 representing the experimental group. Each criterion variable was measured on a continuous scale. Other variables were controlled for since they may have accounted for some of the variance of attitudes towards mathematics and the final algebra score. These variables were sex, frequency of being faced with challenges, and the prior mathematics course grade.

Predictor Variable

Instructional strategies. The use of subjectivist instructional strategies was determined by the section in which the child was placed. It was measured using a categorical variable where 1 represented being in the treatment group, and 0 represented being in the control group.

Attitudes towards mathematics. Students' attitudes towards mathematics were measured using a modified form of the Mathematics Value Inventory (MVI, Luttrell et al., 2010). The MVI measures four subscales: Interest, General Utility, Need for High Achievement and Personal Cost. There are seven questions in each subscale utilizing a

5-point Likert-type response format where 1 indicates strongly disagree and 5 means strongly agree. Some items are reverse-scored and the sum of scores on the questions in each sub-section was used. The Interest subscale measures how fun and interesting students found math. General Utility measures how useful students think math is. The Need for High Achievement subscale measures the importance students attach to making good grades in math. The Personal Cost subscale measures the effort students have to exert to do well in math and how scared they are when faced with math. A higher rating indicates that they find mathematics more challenging and may have to spend more time studying.

As part of the validation process performed by Luttrell and colleagues (2010), the question content was reviewed by multiple mathematics education specialists who helped clarify the descriptions and identify any additional categories to be included. A pilot test was then conducted with actual students who suggested description clarifications and other items to be included. They had to rate how clearly each item was expressed and how easy it was to understand. After review, no additional items were added and clarity ratings for the expert group ranged between 4.2 and 5, with 5 being Excellent. For the student groups, clarity ratings were between 3.84 and 4.79 as they identified the following categories of questions: interest, general utility, need for high achievement and personal cost. Questions in these categories were found to be correlated with $r = .42$ to $.59$. As found in other research, the composite score for each category of interest, utility and achievement were found to be positively correlated with each other, and, inversely correlated with personal cost. The categories were then established as sub-scales and analyzed as such.

To determine reliability, the test was offered twice in two weeks to the same group of 55 undergraduate general education students. The consistency estimates for scores on each subscale of the first test offering correlated with $r = .88$ to $.94$. Consistency for scores on the Interest subscale correlated with $r = .92$. The overall total scale score correlation was $r = .96$. So the MVI scale was found to be internally consistent and its clarity was determined to be consistent across different groups over time (Luttrell et al., 2010).

The research behind the MVI (Luttrell et al., 2010) has been cited in several other attitude and expectancy-value studies (e.g., Akin, Güzeller & Evcan, 2016; Gaspard et al., 2015; Peng, Hong, & Mason, 2014). The MVI itself has been translated into Spanish and re-validated by Rodriguez-Ayan and Rico (2015), and translated into Portuguese by Murimo (2013) who used 14 items from the MVI to measure Grade 7 students' perceptions of the usefulness of mathematics. A self-report inventory developed by Akin and colleagues (2016) was tested with 2,658 students in Grades 6 to 8 in public elementary schools in Turkey. It supported the findings of Luttrell and colleagues (2010) on the MVI that when students have higher expectations and beliefs in themselves, they are also more likely to have higher mathematics achievement.

Unlike Luttrell and colleagues (2010) who tested the MVI with undergraduate general education students, Rodriguez-Ayan and Rico (2015) tested the Spanish MVI with 806 undergraduate students who were majoring in mathematics or science subjects. Factor analysis confirmed mathematics attitudes as a combination of interest, perceived usefulness, perceived achievements possible and personal cost, similar to the dimensions posited by Luttrell and colleagues (2010). However, in analyzing dimensions across

performance, Rodrigues-Ayan and Rico (2015) noticed that as students took more mathematics courses and attained higher achievement scores, they also indicated higher ratings in perceived usefulness and showed a greater need for achievement. However, their interest in mathematics was significantly lower than those who had not persevered thus far. It would therefore seem that the effort to achieve at those heights was at great personal cost which took the edge off the fascination with mathematics. In keeping with this, at the eighth grade there is still the opportunity to raise interest in mathematics that hopefully will lead to higher achievement and persistence in the field.

Although the MVI scale (Luttrell et al., 2010) was validated with undergraduate students, the question meanings can be understood by younger children on the basis of the premise that even students in the first grade were found to value some subjects differently (Eccles et al., 1993). To determine if this instrument is sufficiently straightforward to be understandable to eighth graders in Guyana, the questions were reviewed by various content and student experts in Guyana: the head teachers of three secondary schools, two mathematics department heads, two form teachers and two mathematics secondary school teachers. It was also administered to seventh and eighth grade classes at a different high school in Guyana. These students made suggestions for wording changes which were once again reviewed by two head teachers and two mathematics teachers, then adopted. See Appendix A for the unmodified inventory and Appendix B for details about wording changes.

Pre-treatment attitude towards mathematics. The modified MVI was administered to all students before the treatment began. The raw scores were calculated as the sum of the responses to questions in each subscale. Each subscale was revalidated

to determine its reliability on the basis of Cronbach Alpha. Responses were included for only those questions that gave the highest Cronbach Alpha rating. The pre-treatment attitude towards mathematics variable was continuous and contributed 1 degree of freedom to the GLM.

Criterion Variables

Posttreatment attitude towards mathematics. Students' attitudes towards mathematics were measured again at the end of the treatment using the modified MVI. Scores on this inventory were expected to be higher for the treatment group than for the control group since the control group was not exposed to subjectivist instructional strategies. The raw scores were calculated as the sum of the responses to questions in each subscale. Each subscale was revalidated to determine its reliability on the basis of Cronbach Alpha. Responses were included for only those questions that gave the highest Cronbach Alpha rating. The posttreatment attitude towards mathematics variable was continuous and contributed 1 degree of freedom to the GLM.

Algebra final examination score. Quizzes, examinations and other course assignment grades have been used over time as an indication of achievement in algebra (Li & Ma, 2010). Questions on the Mathematics quizzes and examinations in this grade required students to show the steps of their work with emphasis on the procedural details. In this Mathematics class, quizzes were usually given periodically as each topic was completed and students had to complete other assignments for which they received credit. For the present study, there were two tests given that were common across all Grade 8 sections involved in the study. On the tests, students were required to show their work for all the questions. An end-of-term comprehensive examination was also administered

(see Appendix E). The format of this examination was set to match the national examinations they would take in future grades. As such, the questions were focused on applying procedures. The first section consisted of 5 multiple-choice questions. The second section consisted of 8 questions, from which students had to select and respond to 4, showing their working. The score on this final examination was used as the criterion variable to indicate algebra achievement.

Since common tests and examinations were used, the researcher and the control group teacher developed a grading rubric that was used with all the papers to attempt to make the grading as consistent as possible. Homogeneity tests were performed to determine consistency across sections. The algebra examination score, calculated as a percentage out of 100, was continuous and contributed 1 degree of freedom to the GLM.

Covariates

Three covariates were employed: sex, prior mathematics course score and the challenge index. The sex of the participants was used as the first covariate. Many studies have found that students' attitudes and approaches to studying vary by sex (e.g., Mullis et al., 2011). Sex was treated as a dichotomous variable with 1 representing male and 0 representing female, and therefore contributed one degree of freedom to the GLM.

The score from the Grade 7 end-of-year examination was used as an indicator of prior mathematics achievement. The score was a percentage out of 100 so was treated as continuous and contributed one degree of freedom to the GLM.

The Challenge Index was developed as a way to identify and control for outside influences on students' performance. It incorporates some aspects of the SES measure such as parents' educational level, students' access to educational material in the home,

and access to breakfast. It goes further to ask about how often students received encouragement from family and friends; how often family and friends discourage them; whether they were living at home, with extended family or in some other arrangement (King, et al., 2010); the number of modes of transportation (Mathis & Etzler, 2002); overcrowding in the household; noise level; frequency of disturbances at home; amount of household chores or caretaker duties; sleepiness; time spent “liming” or on social media; and frequency of electrical outages (Budhram, 1994). For most items, they needed to indicate whether the situation occurred Never, Once in a While, Many Times or Every day. The more often the situation occurred, the higher was the challenge index.

The original survey included questions inviting comments about the wording of the questions, and asking for respondents to add any other items that they experienced. It was posted on the Internet and responses sought from a variety of past students from a cross-section of schools in Guyana: secondary departments, high schools and “top” high schools. Correlational analysis was conducted on the 152 responses received and item pairs that had $r > 0.5$ were collapsed together. So, for example, the question about caring for a sick relative was combined with babysitting; liming was combined with social media use; encouragement from other students was combined with encouragement from friends; no one to study with was combined with help with school work; a question was added specifically asking about receiving discouragement; and responders could specify the relationship with the older adult in the home who went to school, such as the aunt, uncle, grandmother and so on.

The modified survey was then re-administered to Grade 8 at one of the leading high schools, and a List “C” high school, both in Guyana. Similar correlations were

analyzed to see if any further changes were needed. The final survey is provided in Appendix D.

Data Analysis

Data analysis was conducted using SPSS for the linear models specified below. First, characteristics were analyzed using descriptive statistics including frequency, mean, standard deviation and homogeneity tests (Tabachnick & Fidell, 2007). Any relationships and patterns were explored by examining correlations, box plots and repeated measures tests. An alpha level of 0.05 was used for all tests. The focus was on analyzing the variance accounted for by multiple variables, some of which were categorical. The two outcome variables may have been dependent on each other so hierarchical general linear models were used. In this way models were created that mirrored the research questions being asked and stepwise regression was avoided by using the general linear model (McNeil et al., 1996).

General Linear Models

To test the hypotheses, linear models were used with the following variables:

- SUBJ = 1 if subjectivist instructional strategies employed
- PMVI = modified MVI subscale pretreatment score
- FMVI = modified MVI subscale posttreatment score
- DMVI = difference between modified MVI scores = FMVI – PMVI
- FALG = score on final examination for algebra section of the course
- SEX = 1 if male, 0 if female
- PMATH = Prior mathematics exam score
- CHLL = combination of challenge variables

H_1 : The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment attitude scores towards mathematics, when controlling for sex, challenges and pre-treatment attitude scores.

Analysis was started by determining what variance was accounted for by sex. Then the pre-treatment attitude score was added to the model to determine any additional variance its presence contributed. The challenge scores were then added to determine any additional variance their presence contributed. The final analysis looked at what additional variance was contributed by adding the use of subjectivist instructional strategies using the model:

$$FMVI = a_0U_1 + a_1SEX + a_2PMVI + a_3CHLL + a_4SUBJ + E_1 \text{ where}$$

a_0U_1 gave the portion of the posttreatment modified MVI score contributed by girls who are not in the subjectivist strategies sections.

a_1 was the coefficient that explained the contribution of sex to the posttreatment modified MVI score.

a_2 was the coefficient that explained the contribution of the pre-treatment modified MVI score to the posttreatment modified MVI score.

a_3 group of coefficients explained the contribution of the challenges to the posttreatment modified MVI score.

a_4 was the coefficient that explained the contribution of the use of subjectivist strategies to the posttreatment modified MVI score. The significance of this coefficient was used to determine whether or not to reject this hypothesis.

The R Square Change column of the Model Summary from SPSS output gave any posttreatment modified MVI score variance accounted for by the strategy use over and above the pre-treatment modified MVI score. The *B* column of the Coefficients table indicated the coefficients for the linear equation for predicting the posttreatment modified MVI score. The Sig. column indicated the significance of the strategy use and whether or not it should be included in predicting posttreatment modified MVI scores.

H_2 : The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment achievement in algebra when controlling for sex, challenges and prior mathematics achievement scores.

Analysis was started by determining what variance was accounted for by sex and challenges. Then the pre-treatment mathematics achievement score was added to the model to determine any additional variance its presence contributed. The final analysis looked at what additional variance was contributed by adding the use of subjectivist instructional strategies using the model:

$$FALG = a_{20}U_1 + a_{21}SEX + a_{22}PMATH + a_{23}CHLL + a_{24}SUBJ + E_2 \text{ where:}$$

$a_{20}U_1$ gave the portion of the posttreatment algebra score contributed by girls who are not in the subjectivist strategies treatment sections.

a_{21} was the coefficient that explained the contribution of sex to the posttreatment algebra score.

a_{22} was the coefficient that explained the contribution of the pre-treatment mathematics score to the posttreatment algebra score.

a_{23} group of coefficients explained the contribution of the challenges to the posttreatment algebra score.

a_{24} was the coefficient that explained the contribution of the use of subjectivist instructional strategies. The significance of this coefficient determined whether or not this hypothesis was rejected.

The R Square Change column of the Model Summary from SPSS output gave any final algebra score variance accounted for by the strategy use over and above the prior mathematics achievement score. The *B* column of the Coefficients table indicated the coefficients for the linear equation for predicting the final algebra score. The Sig. column indicated the significance of the strategy use and whether or not it should be included in predicting final algebra scores.

H_3 : The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment achievement in algebra over and above what is predicted by a difference in attitude scores towards mathematics when controlling for sex, challenges and prior mathematics achievement scores.

Analysis was started by determining what variance was accounted for by sex and challenges. Then the difference in attitude scores and the pre-treatment mathematics achievement score were added to the model to determine any additional variance their presence contributed. The final analysis looked at what additional variance was contributed by adding the use of subjectivist instructional strategies using the model:

$$FALG = a_{30}U_1 + a_{31}SEX + a_{32}DMVI + a_{33}PMATH + a_{34}CHLL + a_{35}SUBJ + E_3$$

where:

$a_{30}U_1$ gave the portion of the posttreatment algebra achievement score contributed by girls who were not in the subjectivist instructional strategy sections.

a_{31} was the coefficient that explained the contribution of sex to the posttreatment algebra achievement score.

a_{32} was the coefficient that explained the contribution of the difference between the pre-treatment modified MVI score and the posttreatment modified MVI score to the posttreatment algebra achievement score.

a_{33} was the coefficient that explained the contribution of the pre-treatment mathematics score to the posttreatment algebra achievement score.

a_{34} group of coefficients explained the contribution of challenges to the posttreatment algebra achievement score.

a_{35} was the coefficient that explained the contribution of the use of subjectivist instructional strategies to the posttreatment algebra achievement score. The significance of this coefficient was used to determine whether or not the hypothesis of subjectivist instructional strategies contributing to post treatment algebra scores was to be rejected.

The R Square Change column of the Model Summary from SPSS output gave any final algebra score variance accounted for by the strategy use over and above the prior mathematics achievement score and the difference in attitude scores. The *B* column of the Coefficients table indicated the coefficients for the linear equation for predicting the final algebra score. The Sig. column indicated the significance of the strategy use and whether or not it should be included in predicting final algebra scores.

CHAPTER IV

IV. RESULTS

This chapter presents the results of the data analysis. It opens with an exploration of the data so that the suitability of challenge scores to act as covariates can be determined. The examination of the hypotheses is then presented.

Descriptive Data and Exploration of Challenge Variables

Background of the Sample

One hundred and fifteen students agreed to take part in the study. However, some were not willing to complete some of the surveys, missed class repeatedly, or did not show up for tests. Those data were therefore removed from the study leaving 89 participants, 42 in the control group and 47 in the experimental group. Of these, 51(57%) were girls and 38(43%) boys, as shown in Figure 10.

Sex	Female	Male	Total
Control	27 (64%)	15 (36%)	42
Experimental	24 (51%)	23 (49%)	47
Total	51 (57%)	38 (43%)	89

Figure 10. Breakdown of sex by study group.

These students came from well-educated families with over 39% of the “father figures” and over 43% of the “mother figures” in the household completing university as shown in Table 1. Over 51% of the “father figures” and over 43% of the “mother figures” completed high school. Between groups about the same percent completed high school or university. 5.6% of the “father figures” either were not present in the

household or did not complete any schooling. 6.7% of the “mother figures” either were not present in the household or did not complete any schooling.

"Father Figure" Education Level	University	Vocational	High School	Primary	None	Total
Control	40.5%	0.0%	50.0%	0.0%	9.5%	42
Experimental	38.3%	2.1%	53.2%	4.3%	2.1%	47
Total	39.3%	1.1%	51.7%	2.2%	5.6%	89
"Mother Figure" Education Level	University	Vocational	High School	Primary	None	Total
Control	45.2%	2.4%	40.5%	4.8%	7.1%	42
Experimental	42.6%	0.0%	46.8%	4.3%	6.4%	47
Total	43.8%	1.1%	43.8%	4.5%	6.7%	89

Table 1. Level of education completed by father and mother figures.

Over 80% of the students lived in households with 5 or more people, and 1 lived in an orphanage with 24 other people in the dorm as shown in Table 2.

Number of People in Household	Fewer than 3	3 - 4	5 - 6	7 - 8	9 - 10	Over 10	Total
Control	2.4%	9.5%	47.6%	31.0%	7.1%	2.4%	42
Experimental	2.1%	21.3%	40.4%	23.4%	12.8%	0.0%	47
Total	2.2%	15.7%	43.8%	27.0%	10.1%	1.1%	89

Table 2. Household size.

The Challenge Index

The challenge index recorded demographic data and responses of how often students were faced with various challenges as shown in Figure 11.

Challenge	Options	Mode	Me- dian	Meaning of the Mode
Number of Modes of Transportation	1 - 3 modes of transportation	0	0	Many use 1 method of transportation
Distance from School	0=Close to school, to 4 furthest away	0	0	Most live within Georgetown area
Living Arrangements	Home/Family/Other	0	0	Most live at home
Number of People in Household	0=fewer than 3, 1=3 or 4, 2=5 - 6, 3=7 - 8, 4=9 - 10, 5 =>10	2	2	Most have more than 5 people in the household
Frequency of Missing Breakfast	Everyday/Most days/ Once in a while/Never	0	0	Most do have breakfast regularly
Highest school level of household member	University/Vocational/ High/Primary/None	2	1	Most parents only went up to high school
Frequency of Family Encouragement	Everyday/Most days/ Once in a while/Never	1	1	Many have others encouraging them
Frequency of others' Encouragement	Everyday/Most days/ Once in a while/Never	2	2	Others rarely provide encouragement
Frequency of Discouragement	N / O / M / E *	0	0	No discouragement
Frequency of not being allowed to study	N / O / M / E *	0	1	Sometimes students are unable to study
Noise Level	N / O / M / E *	1	1	Many are affected by the noise level
Frequency of Disturbances	N / O / M / E *	0	0	Sometimes affected by disturbances in the home
Frequency of Babysitting or Caring for Sick Relative	N / O / M / E *	0	0	Sometimes have to babysit or care for sick relatives
Frequency of Household Chores	N / O / M / E *	1	2	Many times have to do household chores
Frequency of No Adult being Home	N / O / M / E *	0	1	Sometimes no adult is home to encourage studying
Lack of Convenient Study Area	N / O / M / E *	0	0	Sometimes no convenient study area is available
Sleepiness	N / O / M / E *	1	1	Many are too sleepy to study
Lack of Homework Help	N / O / M / E *	0	0	Sometimes no one is available to help with homework
Time spent Liming (hanging out)	N / O / M / E *	0	0	Sometimes spend time liming instead of studying
Blackout Frequency	N / O / M / E *	1	1	Many times there is no electricity
Lack of Resources	N / O / M / E *	0	0	Sometimes no textbook or other study resources available

* N / O / M / E means Never / Once in a while / Most days / Everyday

Figure 11. Challenge index descriptions.

A correlational analysis of the challenge variables was conducted to identify any relationships. It showed a significant medium effect of the correlation between some of the variables. Of note is that the girls seemed more affected by the noise level than the boys ($r = -.313, p < .01$). As shown in Figure 12, lack of family encouragement correlated at $r = .363, p < .01$, considered a medium effect (Cohen, 1992), with students being unable to study. Several other variables also correlated with not being able to study: disturbances ($r = .428, p < .001$); babysitting or caring for a sick relative ($r = .370, p < .001$); and, sleepiness ($r = .335, p < .001$). Sleepiness also seemed to be correlated with several other variables: being unable to study ($r = .335, p < .01$); noise level ($r = .327, p < .01$); disturbances ($r = .345, p < .01$); and, babysitting or caring for a sick relative ($r = .345, p < .01$).

		Correlations						
		Sex	Lack of Family Encouragement	Unable to study	Noise Level	Disturbance	Household Chores	Babysitting or Caring for Sick Relative
Unable to study	Pearson Correlation	0.091	.363**					
	Sig. (2-tailed)	0.403	0.001					
Noise Level	Pearson Correlation	-.313**	-0.051	1				
	Sig. (2-tailed)	0.003	0.642					
Disturbance	Pearson Correlation	0.199	0.179	.428**	1			
	Sig. (2-tailed)	0.063	0.1	0				
Babysitting or Caring for Sick Relative	Pearson Correlation	0.055	0.079	.370**	.371**	1		
	Sig. (2-tailed)	0.608	0.47	0	0			
Sleepiness	Pearson Correlation	-.226*	-0.089	.335**	.327**	.345**	-0.029	.345**
	Sig. (2-tailed)	0.033	0.413	0.001	0.002	0.001	0.785	0.001

Figure 12. Correlations between challenge variables.

To explore these relationships further, a principal factor analysis was done of the challenge variables to identify any possible subscales. Using a Varimax rotation and extracting 4 factors, the matrix in Figure 13 was produced. The variance accounted for by each factor is shown in Figure 14. A reliability analysis was then done on the variables that loaded high in each factor to see if they could be used as a reliable scale score. Only five of the variables in the first factor produced a Cronbach Alpha of .701. The variables included were: Frequency of Disturbances, Frequency of Babysitting or Caring for Sick Relative, Frequency of Household Chores, Sleepiness, and Noise Level. These variables were observed further in the regression analysis of the hypotheses.

Rotated Component Matrix^a				
	Component			
	1	2	3	4
Frequency of Disturbances	0.668	0.086	0.013	0.061
Frequency of Babysitting or Caring for Sick Relative	0.635	0.235	0.032	0.198
Frequency of Household Chores	0.626	0.023	0.042	-0.034
Sleepiness	0.617	0.076	-0.19	0.099
Noise Level	0.55	-0.031	-0.421	-0.024
Lack of Encouragement	0.53	-0.049	0.134	-0.051
Frequency of No Adults home	0.011	0.667	0.116	0.068
Lack of Convenient Study Area	0.29	0.663	-0.033	0.105
Lack of Resources	0.186	0.638	0.115	0.262
Lack of Homework Help	-0.112	0.569	-0.206	-0.125
Parent school level	-0.016	0.537	0.024	-0.436
Lack of Family Encouragement	0.303	0.066	0.631	-0.053
Frequency of Discouragement	0.343	0.069	-0.604	-0.161
Unable to study	0.274	0.321	0.599	-0.179
Modes of Transportation	0.149	0.104	-0.37	0.084
Living Arrangements	0.043	0.316	0.343	0.225
Frequency of Missing Breakfast	0.277	0.104	-0.168	-0.555
Liming	0.096	0.189	-0.214	0.54
Frequency of Electrical Outages	0.12	-0.049	-0.038	0.528

Rotated Component Matrix ^a				
	Component			
	1	2	3	4
People in Household	0.286	0.152	0.128	0.414
Distance from School	0.279	-0.251	0.281	-0.41

Figure 13. Principal factor analysis of challenge variables.

Total Variance Explained			
Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	2.907	13.841	13.841
2	2.334	11.114	24.956
3	1.852	8.820	33.776
4	1.684	8.017	41.793
Extraction Method: Principal Component Analysis.			

Figure 14. Variance accounted for by challenge index factors.

Attitude Scales

The subscales of the modified MVI were used to track students' feelings towards mathematics. The Interest subscale measured how fun and interesting students found math. General Utility measured how useful students thought math was. The Need for High Achievement subscale measured the importance students attached to making good grades in math. The Personal Cost subscale measured the effort students had to exert to do well in math and how scared they were when faced with math. A higher rating indicated that they found mathematics more challenging and had to spend more time studying. Pre-treatment and posttreatment scores were analyzed for reliability, and compared to the original MVI scores (Luttrell et al., 2010). Individual question scores were then removed from the subscale total to achieve the highest Cronbach-Alpha settings, as shown in Figure 15.

Subscale	Luttrell et al., (2010) Reliability Ratings (N=1096)	Pretreatment Modified MVI Ratings	Posttreatment Modified MVI Ratings
Interest	$\alpha = .95$	$\alpha = .744$ (N=119)	$\alpha = .837$ (N=85)
General Utility	$\alpha = .92$	$\alpha = .681$ (N=84)	$\alpha = .640$ (N=85)
Need for Achievement	$\alpha = .92$	$\alpha = .728$ (N=84)	$\alpha = .716$ (N=143)
Personal Cost	$\alpha = .91$	$\alpha = .625$ (N=84)	$\alpha = .688$ (N=143)

Figure 15. Subscale Cronbach Alpha reliability ratings, pre- and posttreatment.

For the Interest subscale, the original MVI Cronbach-Alpha rating was .95 ($N = 1096$); the present study showed $\alpha = .744$ ($N = 119$) on the pretreatment administration, and $\alpha = .837$ ($N = 85$) posttreatment. For the General Utility subscale, the original MVI Cronbach-Alpha rating was .92 ($N = 1096$); the present study showed $\alpha = .681$ ($N = 84$) on the pretreatment administration, and $\alpha = .640$ ($N = 85$) posttreatment. For the Need for Achievement subscale, the original MVI Cronbach-Alpha rating was .92 ($N=1096$); the present study showed $\alpha = .728$ ($N=84$) on the pretreatment administration, and $\alpha = .716$ ($N=143$) posttreatment. For the Personal Cost subscale, the original MVI Cronbach-Alpha rating was .91 ($N=1096$); the present study showed $\alpha = .625$ ($N=84$) on the pretreatment administration, and $\alpha = .688$ ($N=143$) posttreatment.

Subscale Group	Interest		General Utility		Need for Achievement		Personal Cost	
	Before	After	Before	After	Before	After	Before	After
Control	28.28	27.68	27.12	28.12	29.06	30.06	19.23	19.97
Experimental	28.61	28.71	27.02	29.14	29.92	29.41	19.60	18.02
Questions	12, 24, 27, 20, 2, 9	24, 27, 20, 16	3, 17, 13, 6, 10, 23, 21	3, 6, 10	19, 8, 4, 25, 28, 14	19, 8, 4, 25, 28	26, 22, 5, 7, 18	26, 22, 5, 15, 18

Figure 16. Modified MVI before and after scores by group.

Subscales were analyzed individually to get a more in-depth feel for attitudes in the experimental and control groups. Indeed, the outcomes were quite different, as shown in Figure 16. Figure 16 also shows the questions that were included in each

subscale. For the Interest subscale, the control group average score dropped, whereas the experimental group average score rose. For the General Utility subscale, the average score for both groups rose, though the experimental group rose by a greater amount. The Need for Achievement average score rose for the control group but dropped for the experimental group. The Personal Cost average score rose for the control group, but dropped for the experimental group.

Modified MVI subscales and challenge correlations. To determine which challenge variables may show up as covariates, their correlation with the modified MVI subscales was examined. As shown in Figure 17, sex was not correlated significantly with any of the subscales. From the challenge variables, sleep and the noise level once again showed up as contributing to the lack of interest ($r = -.289, p < .01$ and $r = -.224, p < .05$, respectively) while raising the personal cost of doing mathematics ($r = .279, p < .05, r = .264, p < .05$). Except for the medium effect of lack of a convenient study area ($r = .303, p < .01$) and frequency of household chores ($r = .326, p < .01$), the other correlations were considered to have a small effect so they were not expected to show up in the regressions.

Correlations		Interest Score	Utility Score	Need for Achievement Score	Personal Cost Score
Sex	Pearson Correlation	0.117	0.113	-0.135	-0.194
	Sig. (2-tailed)	0.288	0.302	0.219	0.075
Modes of Transportation	Pearson Correlation	-0.058	0.059	-0.012	-0.048
	Sig. (2-tailed)	0.598	0.594	0.916	0.664
Distance from School	Pearson Correlation	-0.085	0.114	0.02	0.106
	Sig. (2-tailed)	0.437	0.298	0.854	0.333
Living Arrangements	Pearson Correlation	0.05	-0.113	.245*	-0.03
	Sig. (2-tailed)	0.646	0.303	0.024	0.783
Number of People in	Pearson Correlation	-0.001	0.028	0.169	0

Correlations		Interest Score	Utility Score	Need for Achievement Score	Personal Cost Score
Household	Sig. (2-tailed)	0.989	0.801	0.121	0.997
Frequency of Missing Breakfast	Pearson Correlation	-0.093	0.119	-0.069	.245 ⁺
	Sig. (2-tailed)	0.396	0.276	0.528	0.024
Highest school level of household member	Pearson Correlation	0.015	0.038	-0.088	0.106
	Sig. (2-tailed)	0.892	0.729	0.422	0.335
Frequency of Family Encouragement	Pearson Correlation	-0.18	0.095	0.047	-0.055
	Sig. (2-tailed)	0.103	0.391	0.675	0.621
Lack of Encouragement from Others	Pearson Correlation	-0.066	.286 ^{**}	-0.055	0.11
	Sig. (2-tailed)	0.553	0.009	0.623	0.321
Frequency of Discouragement	Pearson Correlation	-0.058	.260 ⁺	0.074	.274 ⁺
	Sig. (2-tailed)	0.602	0.017	0.504	0.012
Frequency of not being allowed to study	Pearson Correlation	0	-0.015	-0.009	0.038
	Sig. (2-tailed)	1	0.89	0.937	0.736
Noise Level	Pearson Correlation	-.224 ⁺	0.188	-0.013	.264 ⁺
	Sig. (2-tailed)	0.04	0.085	0.905	0.015
Frequency of Disturbances	Pearson Correlation	-0.127	0.212	-0.034	0.198
	Sig. (2-tailed)	0.249	0.053	0.758	0.071
Babysitting or Caring for Sick Relative	Pearson Correlation	0	.217 ⁺	-0.002	0.201
	Sig. (2-tailed)	0.998	0.046	0.985	0.065
Frequency of Household Chores	Pearson Correlation	-0.01	.326 ^{**}	0.19	0.133
	Sig. (2-tailed)	0.924	0.002	0.081	0.226
Frequency of No Adult being Home	Pearson Correlation	-0.092	0.178	0.074	0.156
	Sig. (2-tailed)	0.404	0.102	0.503	0.153
Lack of Convenient Study Area	Pearson Correlation	-.288 ^{**}	0.062	-0.094	.303 ^{**}
	Sig. (2-tailed)	0.008	0.574	0.396	0.005
Sleepiness	Pearson Correlation	-.289 ^{**}	0.088	-0.001	.279 ^{**}
	Sig. (2-tailed)	0.007	0.423	0.991	0.01
Lack of Homework Help	Pearson Correlation	0.158	0.002	-0.002	0.043
	Sig. (2-tailed)	0.15	0.989	0.986	0.699
Time spent Hanging Out	Pearson Correlation	-0.137	-0.092	0.006	0.133
	Sig. (2-tailed)	0.214	0.406	0.954	0.227
Frequency of Electricity Outages	Pearson Correlation	-0.123	-0.125	-0.076	-0.11
	Sig. (2-tailed)	0.263	0.253	0.489	0.314
Lack of Resources	Pearson Correlation	-.270 ⁺	-0.193	-0.03	.258 ⁺
	Sig. (2-tailed)	0.012	0.077	0.787	0.017

Figure 17. Correlations between modified MVI posttreatment subscales and challenge variables.

Interest subscale. Analysis of the Interest subscale pre- and posttreatment using the Repeated Measures Test, showed first of all that the control and experimental groups were homogeneous in the variances. However, no significant change over time between pre- and posttreatment scores was noted: Wilks' lambda = 0.997, $F(1,78) = .213$, $p > 0.5$. After the treatment, the experimental group found algebra more interesting whereas the control group found it less interesting, but the difference was not significant, as shown in Figure 18. Since these differences were not significant, no covariate analysis was done.

Figure 18. Repeated measures analysis of modified MVI interest subscale.

Utility subscale. For the Utility subscale, the frequency of household chores challenge variable showed a medium effect correlation ($r = .326$, $p < .01$), so a box plot was created to see what the relationship looked like. As shown in Figure 19, there appeared to be a linear relationship in that as the chores increased, rather than serve as a deterrent for mathematics - maybe students were beginning to see in the real world some of what was being discussed in class (Kliman, 1999).

Figure 19. Boxplot of relationship between posttreatment utility score and frequency of household chores.

Analysis of the Utility subscale pre- and posttreatment using the Repeated Measures Test, showed first of all that the control and experimental groups were homogeneous in the variances. Over time the change in utility scores was significant, Wilks' lambda = 0.921, $F(1,78) = 6.723$, $p < 0.5$. As shown in Figure 19, scores for both groups increased with the experimental group's score increasing more rapidly. However, the difference between the groups was not significant. Applying the covariate of frequency of household chores, the change in utility score over time was still significant [Wilk's lambda = 0.936, $F(1,78) = 5.288$, $p < .05$], but the difference between the groups over time was still not significant.

Multivariate Tests ^a							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
MVIUtility	Wilks' Lambda	0.921	6.723 ^b	1.000	78.000	0.011	0.079
MVIUtility * Group	Wilks' Lambda	0.991	.677 ^b	1.000	78.000	0.413	0.009

a. Design: Intercept + Group
Within Subjects Design: MVIUtility

b. Exact statistic

Figure 20. Repeated measures analysis of modified MVI utility subscale.

Need for achievement subscale. Analysis of the Need for Achievement subscale pre- and posttreatment using the Repeated Measures Test, showed that the control and experimental groups were homogeneous in the variances. However, no significant change over time between pre- and posttreatment scores was noted as shown in Figure 21. After the treatment, the control group had a higher need for achievement than the experimental group, but the difference was not significant. Since these differences were not significant, no covariate analysis was done.

Levene's Test of Equality of Error Variances ^a				
	F	df1	df2	Sig.
Pretreatment Need for Achievement Score	0.515	1	78	0.475
Posttreatment Need for Achievement Score	2.481	1	78	0.119

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Group

Within Subjects Design: MVINeedAchievement

Figure 21. Repeated measures analysis of modified MVI need for achievement subscale.

Personal cost subscale. For the Personal Cost subscale, the frequency of lack of convenient study space challenge variable showed a medium effect correlation ($r = .303$, $p < .01$), so a box plot was created to see what the relationship looked like. The box plot did not show linearity (see Figure 22) so this variable was not included as a covariate in the repeated measures test.

Figure 22. Boxplot of relationship between posttreatment utility score and lack of convenient study area.

The Repeated Measures test showed that the groups were homogeneous. After treatment, the control group was higher on the Personal Cost subscale than the Experimental group. This indicates that they find Math more challenging than the Experimental group. However, the difference was not significant.

Achievement

Two tests and one end of term examination were given in Grade 8 as part of the study. Grade 8 Test 1 was given during the sixth week of the term. Topics included adding and multiplying positive and negative numbers; Using the Distributive Law with numbers only; Degree of a polynomial; and, starting to convert word expressions to algebraic expressions. Test 2 was given during the 10th week. Included were:

Simplifying algebraic expressions; Substitution; Indices; Binary operations; Solving simple equations by inspection; and, Basic factorization (reverse of Distributive Law).

The Grade 8 Exam covered all topics for the term. Figure 23 shows the way that scores changed between the groups. In Grade 7, the average achievement score for the experimental group was higher than the control group. However, in Grade 8, the control group average was higher than the experimental group on both tests and the examination.

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
Grade 7 Exam	Control	41	48.09	15.41	2.41
	Experimental	47	49.86	16.00	2.33
Grade 8 Test 1	Control	42	32.02	18.81	2.90
	Experimental	43	31.22	20.36	3.10
Grade 8 Test 2	Control	42	21.62	17.22	2.66
	Experimental	45	17.33	12.45	1.86
Grade 8 Exam	Control	42	33.92	20.06	3.10
	Experimental	47	23.28	13.44	1.96

Figure 23. Test scores over time.

To see how students' achievement progressed over time, a repeated measures test was done, starting with the Grade 7 final examination. Achievement scores changed significantly over time and the difference between the control and experimental groups was also significant, as seen in Figure 24: Wilk's lambda = 0.257, $F(3, 78) = 75.174$, $p < 0.001$; and Wilk's Lambda = 0.836, $F(3, 78) = 5.098$, $p < 0.01$, respectively. Pairwise comparisons showed that the Grade 7 Exam score was significantly different from all the Grade 8 tests/exam. However, only the Grade 8 Test 2 score was significantly different from the other scores. This was the lowest score of all, at the time when the students were really getting into working with variables and equations and manipulating algebraic

expressions including using the Distributive Law. By the final examination, they had practiced more and were getting used to the idea of variables.

Figure 24. Repeated measures analysis of achievement.

To analyze more closely the change in scores between the groups, an Independent Samples Test was performed. This test showed that the significant difference between groups occurred on the Grade 8 examination where the average achievement score for the control group was higher than that of the experimental group as shown in Figure 25. The mean difference was 9.317, $t = 2.91$, $df = 70.40$, $p < 0.01$.

Independent Samples Test								
		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Grade 7 Exam	Equal variances assumed	0.215	0.644	-0.53	86	0.600	-1.77	3.36
Grade 8 Test 1	Equal variances assumed	0.122	0.727	0.19	83	0.851	0.80	4.25
Grade 8 Test 2	Equal variances assumed	4.573	0.035	1.34	85	0.185	4.29	3.21
	Equal variances not assumed			1.32	74.293	0.190	4.29	3.24
Grade 8 Exam	Equal variances assumed	5.575	0.020	2.97	87	0.004	10.64	3.59
	Equal variances not assumed			2.91	70.400	0.005	10.64	3.66

Figure 25. Independent samples test of achievement over time.

Achievement and challenge correlations. In looking at correlations between achievement and the challenge variables, only one variable showed up significantly across the board with small to medium negative effects: Number of modes of transportation each day. A box plot (see Figure 26) showed a definite pattern in that the fewer the modes of transportation, the higher was the average achievement score. Correlations ranged between $-.380$ and $-.225$, all at significance level < 0.05 .

Figure 26. Box plot of relationship between modes of transportation and achievement on Grade 8 exam.

Hypothesis Analysis

Three hypotheses were analyzed using hierarchical linear regression. The model hypothesized that the pretreatment attitude scores predicted the posttreatment attitude scores, and, together with the pretreatment achievement scores, predicted the posttreatment achievement scores. The attitude scores have four subscales so these were analyzed separately. Analysis began by verifying the underlying assumptions for regression analysis were met, namely: (a) homogeneity of variance between groups; (b) a linear relationship existed between the predictor and criterion variables; (c) independent scores across study groups; (d) criterion variables were normally distributed across all values of the predictor variable; and, (e) homoscedasticity existed, that is, any residual error is consistent for all values of the predictor variables (Osborne & Waters, 2002).

Assumption Testing

Analysis of the posttreatment attitude subscales using the homogeneity of variance test on the one-way ANOVA showed that the variances were homogeneous across study groups. However, there was a small violation of homogeneity of variance between study groups for the achievement score as shown in Figure 27.

Test of Homogeneity of Variances				
	Levene Statistic	df1	df2	Sig.
Posttreatment Interest Score	0.441	1	83	0.508
Posttreatment Utility Score	0.043	1	83	0.835
Posttreatment Need for Achievement Score	1.223	1	83	0.272
Posttreatment Personal Cost Score	2.494	1	83	0.118
Grade 8 Exam	5.575	1	87	0.020

Figure 27. Homogeneity of variances of dependent variables across study groups.

Linearity was determined by looking at scatter plots between the predictor variable and each criterion variable. Since there are only two groups, linearity is assumed as shown in Figure 28.

Figure 28. Scatter plots of predictor against criterion variables.

Independence of the criterion data can be assumed since it was collected from each participant confidentially. Final exams were also done in a proctored environment to minimize possibilities of copying work.

Analysis of normality was conducted using the Explore option in SPSS. The Kolmogorov-Smirnov test indicated that the Posttreatment Personal Cost Score distribution was normal in both groups since the statistic was not significant. For the control group, the Posttreatment Interest Score and the Posttreatment Need for

Achievement Score distributions were also normal, as shown in Figure 29. Figure 30 shows the scores that were normally distributed.

Tests of Normality							
Group		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Grade 8 Exam	Control	0.179	38	0.003	0.908	38	0.004
	Experimental	0.149	47	0.010	0.917	47	0.003
Posttreatment Interest Score	Control	0.121	38	0.171	0.946	38	0.066
	Experimental	0.197	47	0.000	0.853	47	0.000
Posttreatment Utility Score	Control	0.173	38	0.006	0.904	38	0.003
	Experimental	0.186	47	0.000	0.855	47	0.000
Posttreatment Need for Achievement Score	Control	0.112	38	.200	0.952	38	0.100
	Experimental	0.147	47	0.013	0.954	47	0.063
Posttreatment Personal Cost Score	Control	0.094	38	.200	0.977	38	0.626
	Experimental	0.106	47	.200	0.936	47	0.013
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Figure 29. Normality tests for criterion variables with normal outcomes highlighted.

Figure 30. Histograms Showing normal distributions across predictor variable groups.

The lack of normality was also shown by the Normal Q-Q plot of each criterion variable as shown in Figures 31 and 32. Scores that cluster around the reference line indicate that the observed distribution is the same as the expected normal distribution so the dataset would be considered normal.

Figure 31. Criterion variable Q-Q plots with normal distributions highlighted.

Figure 32. Criterion variable Q-Q plots with normal distributions highlighted.

The Detrended Normal Q-Q Plots of the criterion variables for each group enabled homoscedasticity to be examined. Similar to the Normal Q-Q plots, the outliers caused distances from the zero line to vary, indicating that the residual error is not the same throughout the distribution. Though there was some violation of the normality and homoscedasticity assumptions, further analysis with the general linear model is still possible as the GLM's robustness enables accommodation of these variations.

Analysis of Hypothesis H_1

Hypothesis H_1 posited that the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana would account for a

significant amount of variance in predicting posttreatment attitude scores towards mathematics, when controlling for sex, challenges and pre-treatment attitude scores. Each attitude score was analyzed separately. So results will be presented for the following sub-hypotheses:

H₁₁: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment interest subscale scores towards mathematics, when controlling for sex, pre-treatment interest subscale scores, and challenges.

H₁₂: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment utility subscale scores towards mathematics, when controlling for sex, pre-treatment utility subscale scores, and challenges.

H₁₃: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment need for achievement subscale scores towards mathematics, when controlling for sex, pre-treatment need for achievement subscale scores, and challenges.

H₁₄: The use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounts for a significant amount of variance in predicting posttreatment personal cost subscale scores towards mathematics, when controlling for sex, pre-treatment personal cost subscale scores, and challenges.

The interest subscale H_{II} . Sex was introduced into the model first, followed by the pretreatment interest score, then the challenge scores and finally the study group indicator. As shown in Figure 33, entry of sex into the model was not significant. However, sex and the pretreatment interest score accounted for a significant amount of variance in the posttreatment interest score ($R = .381, p < .01$). Adding in the challenge variables accounted for a significant amount of variance ($R = .765, p < .01$). Adding the teaching method did not contribute any additional significant amount of variance.

Model Summary ^e									
Model	<i>R</i>	<i>R</i> Square	Adjusted <i>R</i> Square	Std. Error of the Estimate	<i>R</i> Square Change	Change Statistics			Sig. <i>F</i> Change
						<i>F</i> Change	df1	df2	
1	.123 ^a	0.015	0.001	5.89252	0.015	1.050	1	68	0.309
2	.381 ^b	0.145	0.119	5.53130	0.130	10.172	1	67	0.002
3	.765 ^c	0.585	0.378	4.64821	0.440	2.327	21	46	0.008
4	.765 ^d	0.585	0.364	4.69948	0.000	0.002	1	45	0.966
a. Predictors: (Constant), Sex									
b. Predictors: (Constant), Sex, Pretreatment Interest Score									
c. Predictors: (Constant), Sex, Pretreatment Interest Score, Living Arrangements, Distance from School, Sleepiness, Parent school level, Lack of Homework Help, Electrical Outages, Disturbance, Frequency of Discouragement, Modes of Transportation, People in Household, Lack of Encouragement, Lack of Family Encouragement, No Convenient Study Area, Liming, Noise Level, No Adult home, Unable to study, Frequency of Household Chores, Frequency of Missing Breakfast, Babysitting or Caring for Sick Relative, Lack of Resources									
d. Predictors: (Constant), Sex, Pretreatment Interest Score, Living Arrangements, Distance from School, Sleepiness, Parent school level, Lack of Homework Help, Electrical Outages, Disturbance, Frequency of Discouragement, Modes of Transportation, People in Household, Lack of Encouragement, Lack of Family Encouragement, No Convenient Study Area, Liming, Noise Level, No Adult home, Unable to study, Frequency of Household Chores, Frequency of Missing Breakfast, Babysitting or Caring for Sick Relative, Lack of Resources, Group									
e. Dependent Variable: Posttreatment Interest Score									

Figure 33. Regression analysis of posttreatment interest subscale.

Further analysis of the significant effects showed the pretreatment interest score contributed 13% of the variance of the posttreatment interest score over and above that contributed by sex, and can be used to significantly predict the posttreatment interest score with $B = .466, p < .01$. The challenge variables contributed an additional 44% of

the variance of the posttreatment interest score drowning out the negligible amount contributed by the teaching method.

As shown in Figure 34, several of the challenge variables can be used to significantly predict the posttreatment interest subscale score: Living Arrangements ($p < .05$); Lack of Family Encouragement ($p < .01$); No Adult Being Home ($p < .01$); No Convenient Study Area ($p < .01$); Sleepiness ($p < .03$); and Lack of Homework Help ($p < .02$). Some variables are positively correlated with the posttreatment score: Living Arrangements and Lack of Homework Help, indicating that living with extended family and not having homework help tends to raise the interest in mathematics. However, as expected, other variables: No Adult Home; No Convenient Study Area; and, Sleepiness, were negatively correlated indicating that the absence of this support reduced interest in mathematics. Being in the treatment group did not make a significant contribution to the variance and so cannot be used to significantly predict the posttreatment interest subscale score. Hypothesis H_{11} is therefore rejected.

Coefficients ^a					
Model		Unstandardized Coefficients		Standardized Coefficients	
		B	Std. Error	Beta	t
1	(Constant)	27.300	0.932		29.302
	Sex	1.458	1.423	0.123	1.025
2	(Constant)	13.894	4.294		3.236
	Sex	1.794	1.340	0.152	1.339
	Pretreatment Interest Score	0.466	0.146	0.361	3.189
3	(Constant)	13.801	4.662		2.960
	Sex	0.990	1.413	0.084	0.700
	Pretreatment Interest Score	0.678	0.149	0.525	4.535
	Modes of Transportation	-0.228	1.234	-0.022	-0.185
	Distance from School	-0.008	0.850	-0.001	-0.010
	Living Arrangements	3.782	1.727	0.251	2.189
	People in Household	-1.418	0.715	-0.241	-1.982

Coefficients ^a					
Model	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	Sig.
	<i>B</i>	Std. Error	Beta		
Frequency of Missing Breakfast	-0.787	0.796	-0.131	-0.988	0.328
Parent school level	0.970	0.651	0.171	1.491	0.143
Lack of Family Encouragement	-3.839	1.203	-0.413	-3.190	0.003
Lack of Encouragement	1.355	0.821	0.210	1.651	0.106
Frequency of Discouragement	-0.839	0.861	-0.125	-0.975	0.335
Unable to study	0.776	0.855	0.115	0.908	0.369
Noise Level	-1.433	0.797	-0.236	-1.798	0.079
Disturbance	0.635	0.925	0.085	0.687	0.495
Babysitting or Caring for Sick Relative	1.269	0.951	0.189	1.335	0.189
Frequency of Household Chores	0.785	0.809	0.135	0.970	0.337
No Adult home	-2.677	0.783	-0.450	-3.419	0.001
No Convenient Study Area	-2.617	0.888	-0.398	-2.947	0.005
Sleepiness	-2.286	0.998	-0.332	-2.290	0.027
Lack of Homework Help	2.343	0.907	0.325	2.583	0.013
Liming	-0.476	0.816	-0.070	-0.583	0.563
Electrical Outages	-0.629	1.200	-0.060	-0.524	0.602
Lack of Resources	1.694	1.260	0.228	1.344	0.185
a. Dependent Variable: Posttreatment Interest Score					

Figure 34. Truncated coefficient list of posttreatment interest regression analysis.

The utility subscale H_{12} . Sex was introduced into the model first, followed by the pretreatment utility score, then the challenge scores and finally the study group indicator. Entry of sex into the model was not significant as shown in Figure 35. However, sex and the pretreatment utility score accounted for a significant amount of variance in the posttreatment utility score ($R = .396, p < .01$). Adding in the challenge variables did not contribute any additional significant amount of variance, nor did adding in membership in the treatment group.

Model Summary ^e									
Model	<i>R</i>	<i>R</i> Square	Adjusted <i>R</i> Square	Std. Error of the Estimate	<i>R</i> Square Change	Change Statistics			Sig. <i>F</i> Change
						<i>F</i> Change	df1	df2	
1	.176 ^a	0.031	0.017	6.16461	0.031	2.178	1	68	0.145
2	.396 ^b	0.157	0.132	5.79204	0.126	10.029	1	67	0.002
3	.660 ^c	0.436	0.153	5.72076	0.278	1.080	21	46	0.400
4	.674 ^d	0.454	0.163	5.68856	0.018	1.522	1	45	0.224

a. Predictors: (Constant), Sex

b. Predictors: (Constant), Sex, Pretreatment Utility Score

c. Predictors: (Constant), Sex, Pretreatment Utility Score, Parent school level, Frequency of Missing Breakfast, Babysitting or Caring for Sick Relative, Lack of Family Encouragement, Frequency of Discouragement, Liming, Living Arrangements, Modes of Transportation, Sleepiness, Electrical Outages, People in Household, No Convenient Study Area, Distance from School, Lack of Encouragement, Disturbance, No Adult home, Unable to study, Lack of Homework Help, Noise Level, Frequency of Household Chores, Lack of Resources

d. Predictors: (Constant), Sex, Pretreatment Utility Score, Parent school level, Frequency of Missing Breakfast, Babysitting or Caring for Sick Relative, Lack of Family Encouragement, Frequency of Discouragement, Liming, Living Arrangements, Modes of Transportation, Sleepiness, Electrical Outages, People in Household, No Convenient Study Area, Distance from School, Lack of Encouragement, Disturbance, No Adult home, Unable to study, Lack of Homework Help, Noise Level, Frequency of Household Chores, Lack of Resources, Group

e. Dependent Variable: Posttreatment Utility Score

Figure 35. Regression model summary for posttreatment utility subscale scores.

Further analysis of the significant effects showed the pretreatment utility score contributed 12.6% of the variance of the posttreatment utility score over and above that contributed by sex alone, and can be used to significantly predict the posttreatment utility score with $B = .444$, $p < .01$ as shown in Figure 36. Neither the challenge variables nor being in the treatment group contributed significantly to the variance so neither can be used to significantly predict the posttreatment utility subscale score. Hypothesis H_{12} is therefore rejected.

Coefficients ^a					
Model		Unstandardized Coefficients		Standardized Coefficients Beta	
		B	Std. Error		t
1	(Constant)	27.358	0.975		28.068
	Sex	2.197	1.489	0.176	1.476
2	(Constant)	15.526	3.847		4.036
	Sex	2.157	1.399	0.173	1.542
	Pretreatment Utility Score	0.444	0.140	0.355	3.167
a. Dependent Variable: Posttreatment Utility Score					

Figure 36. Truncated coefficient list of posttreatment utility regression analysis.

The need for achievement subscale H_{13} . Sex was introduced into the model first, followed by the pretreatment need for achievement score, then the challenge scores and finally the study group indicator. Entry of sex into the model was not significant. However, sex and the pretreatment need for achievement score accounted for a significant amount of variance ($R = .524, p < .001$). The challenge variables did not contribute any additional significant amount of variance, nor did membership in the treatment group as shown in Figure 37.

Further analysis of the significant effects showed the pretreatment need for achievement score contributed 26.1% of the variance of the posttreatment need for achievement score over and above that contributed by sex, and can be used to significantly predict the posttreatment need for achievement score with $B = .437, p < .001$ as shown in Figure 38. The challenge variables did not contribute significantly to the variance so cannot be used to significantly predict the posttreatment need for achievement subscale score. Likewise, being in the treatment group did not make a significant contribution to the variance and so cannot be used to significantly predict the posttreatment need for achievement subscale score. Hypothesis H_{13} is therefore rejected.

Model Summary ^e									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics F Change	df1	df2	Sig. F Change
1	.117 ^a	0.014	-0.001	3.76569	0.014	0.946	1	68	0.334
2	.524 ^b	0.274	0.253	3.25425	0.261	24.054	1	67	0.000
3	.669 ^c	0.447	0.171	3.42826	0.173	0.684	21	46	0.826
4	.679 ^d	0.461	0.174	3.42053	0.014	1.208	1	45	0.278
a. Predictors: (Constant), Sex									
b. Predictors: (Constant), Sex, Pretreatment Need for Achievement Score									
c. Predictors: (Constant), Sex, Pretreatment Need for Achievement Score, Parent school level, Sleepiness, People in Household, Electrical Outages, Frequency of Discouragement, Distance from School, Living Arrangements, Lack of Encouragement, Lack of Homework Help, Modes of Transportation, Frequency of Household Chores, No Convenient Study Area, Noise Level, Liming, No Adult home, Unable to study, Lack of Family Encouragement, Disturbance, Babysitting or Caring for Sick Relative, Frequency of Missing Breakfast, Lack of Resources									
d. Predictors: (Constant), Sex, Pretreatment Need for Achievement Score, Parent school level, Sleepiness, People in Household, Electrical Outages, Frequency of Discouragement, Distance from School, Living Arrangements, Lack of Encouragement, Lack of Homework Help, Modes of Transportation, Frequency of Household Chores, No Convenient Study Area, Noise Level, Liming, No Adult home, Unable to study, Lack of Family Encouragement, Disturbance, Babysitting or Caring for Sick Relative, Frequency of Missing Breakfast, Lack of Resources, Group									
e. Dependent Variable: Posttreatment Need for Achievement Score									

Figure 37. Regression model summary for posttreatment need for achievement subscore.

Coefficients ^a					
Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1 (Constant)	29.663	0.595		49.819	0.000
Sex	-0.885	0.910	-0.117	-0.973	0.334
2 (Constant)	16.419	2.749		5.973	0.000
Sex	-0.002	0.806	0.000	-0.002	0.998
Pretreatment Need for Achievement Score	0.437	0.089	0.524	4.904	0.000
a. Dependent Variable: Posttreatment Need for Achievement Score					

Figure 38. Truncated coefficient list of posttreatment need for achievement regression analysis.

The personal cost subscale H_{14} . Sex was introduced into the model first, followed by the pretreatment personal cost score, then the challenge scores and finally the study group indicator. Entry of sex into the model was not significant. However, adding

the pretreatment personal cost score accounted for a significant amount of variance ($r = .429, p < .01$) as shown in Figure 39. Adding the challenge variables also accounted for a significant amount of variance ($r = .761, p < .05$) as did adding the teaching method ($r = .792, p < .02$).

Model Summary ^e									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.221 ^a	0.049	0.035	5.78473	0.049	3.499	1	68	0.066
2	.429 ^b	0.184	0.160	5.39761	0.135	11.104	1	67	0.001
3	.761 ^c	0.579	0.368	4.68191	0.394	2.050	21	46	0.021
4	.792 ^d	0.628	0.429	4.44984	0.049	5.923	1	45	0.019
a. Predictors: (Constant), Sex									
b. Predictors: (Constant), Sex, Pretreatment Personal Cost Score									
c. Predictors: (Constant), Sex, Pretreatment Personal Cost Score, Living Arrangements, Modes of Transportation, Liming, Sleepiness, Lack of Family Encouragement, Parent school level, Frequency of Discouragement, Frequency of Missing Breakfast, People in Household, No Convenient Study Area, Noise Level, Electrical Outages, Lack of Encouragement, No Adult home, Frequency of Household Chores, Unable to study, Disturbance, Lack of Homework Help, Distance from School, Babysitting or Caring for Sick Relative, Lack of Resources									
d. Predictors: (Constant), Sex, Pretreatment Personal Cost Score, Living Arrangements, Modes of Transportation, Liming, Sleepiness, Lack of Family Encouragement, Parent school level, Frequency of Discouragement, Frequency of Missing Breakfast, People in Household, No Convenient Study Area, Noise Level, Electrical Outages, Lack of Encouragement, No Adult home, Frequency of Household Chores, Unable to study, Disturbance, Lack of Homework Help, Distance from School, Babysitting or Caring for Sick Relative, Lack of Resources, Group									
e. Dependent Variable: Posttreatment Personal Cost Score									

Figure 39. Regression model summary for posttreatment personal cost subscale.

Further analysis of the significant effects showed the pretreatment personal cost score contributed 13.5% of the variance of the posttreatment personal cost score over and above that contributed by sex, and can be used to significantly predict the posttreatment personal cost score with $B = .380, p < .01$ as shown in Figure 40. The challenge variables contributed an additional 39.4% of the variance of the posttreatment personal cost score and the teaching method accounted for an additional 4.9%.

Coefficients ^a								
Model		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error				Lower Bound	Upper Bound
1	(Constant)	19.740	0.915		21.582	0.000	17.915	21.565
	Sex	-2.613	1.397	-0.221	-1.870	0.066	-5.401	0.175
2	(Constant)	12.234	2.409		5.079	0.000	7.427	17.042
	Sex	-2.671	1.304	-0.226	-2.049	0.044	-5.273	-0.069
	Pretreatment Personal Cost Score	0.380	0.114	0.368	3.332	0.001	0.152	0.607
3	(Constant)	11.464	3.646		3.144	0.003	4.125	18.802
	Sex	-1.556	1.387	-0.132	-1.122	0.268	-4.348	1.236
	Pretreatment Personal Cost Score	0.280	0.118	0.271	2.364	0.022	0.042	0.518
	Modes of Transportation	-2.734	1.203	-0.259	-2.273	0.028	-5.154	-0.313
	Distance from School	0.321	0.865	0.047	0.371	0.712	-1.420	2.063
	Living Arrangements	-1.412	1.714	-0.094	-0.823	0.414	-4.862	2.039
	People in Household	-0.004	0.700	-0.001	-0.006	0.995	-1.413	1.404
	Frequency of Missing Breakfast	1.146	0.802	0.192	1.428	0.160	-0.470	2.761
	Parent school level	-0.069	0.654	-0.012	-0.105	0.917	-1.384	1.247
	Lack of Family Encouragement	0.349	1.211	0.038	0.288	0.775	-2.089	2.786
	Lack of Encouragement	-0.327	0.830	-0.051	-0.394	0.695	-1.998	1.344
	Frequency of Discouragement	1.620	0.855	0.242	1.895	0.064	-0.101	3.340
	Unable to study	-0.720	0.852	-0.107	-0.845	0.402	-2.434	0.995
	Noise Level	1.458	0.812	0.240	1.795	0.079	-0.177	3.092
	Disturbance	-0.074	0.930	-0.010	-0.080	0.937	-1.945	1.797
	Babysitting or Caring for Sick Relative	-0.673	0.978	-0.101	-0.688	0.495	-2.642	1.295
	Frequency of Household Chores	0.054	0.818	0.009	0.066	0.948	-1.593	1.701
	No Adult home	1.313	0.752	0.221	1.746	0.087	-0.201	2.828
	No Convenient Study Area	1.586	0.895	0.241	1.771	0.083	-0.216	3.388
	Sleepiness	0.972	1.006	0.141	0.966	0.339	-1.053	2.997
	Lack of Homework Help	-1.840	0.915	-0.255	-2.011	0.050	-3.682	0.002
	Liming	0.778	0.833	0.115	0.934	0.355	-0.898	2.454

Coefficients ^a							
Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error				Lower Bound	Upper Bound
4	Electrical Outages	-0.675	1.227	-0.065	-0.550	0.585	-3.145 1.795
	Lack of Resources	0.729	1.240	0.098	0.588	0.560	-1.768 3.226
	(Constant)	12.183	3.478		3.503	0.001	5.179 19.187
	Sex	-1.082	1.333	-0.092	-0.812	0.421	-3.766 1.602
	Pretreatment Personal Cost Score	0.322	0.114	0.312	2.833	0.007	0.093 0.552
	Modes of Transportation	-2.462	1.148	-0.233	-2.144	0.038	-4.775 -0.149
	Distance from School	0.122	0.826	0.018	0.147	0.883	-1.543 1.786
	Living Arrangements	-1.046	1.636	-0.070	-0.640	0.526	-4.342 2.249
	People in Household	-0.388	0.683	-0.066	-0.568	0.573	-1.765 0.988
	Frequency of Missing Breakfast	1.075	0.763	0.180	1.408	0.166	-0.462 2.612
	Parent school level	0.119	0.626	0.021	0.190	0.850	-1.142 1.380
	Lack of Family Encouragement	-0.003	1.160	0.000	-0.003	0.998	-2.339 2.333
	Lack of Encouragement	-0.009	0.800	-0.001	-0.012	0.991	-1.620 1.601
	Frequency of Discouragement	1.110	0.839	0.166	1.324	0.192	-0.579 2.800
	Unable to study	-0.561	0.812	-0.083	-0.691	0.493	-2.197 1.075
	Noise Level	1.862	0.789	0.307	2.359	0.023	0.272 3.451
	Disturbance	0.159	0.889	0.021	0.179	0.858	-1.630 1.949
	Babysitting or Caring for Sick Relative	-0.503	0.932	-0.075	-0.539	0.592	-2.380 1.375
	Frequency of Household Chores	0.075	0.778	0.013	0.097	0.923	-1.491 1.642
	No Adult home	0.983	0.728	0.166	1.351	0.183	-0.483 2.449
	No Convenient Study Area	0.855	0.902	0.130	0.948	0.348	-0.962 2.673
	Sleepiness	1.022	0.956	0.149	1.069	0.291	-0.904 2.948
	Lack of Homework Help	-1.982	0.872	-0.275	-2.274	0.028	-3.738 -0.226
	Liming	1.046	0.799	0.155	1.309	0.197	-0.563 2.656
	Electrical Outages	-0.604	1.167	-0.058	-0.517	0.607	-2.954 1.746
	Lack of Resources	0.911	1.181	0.123	0.772	0.444	-1.468 3.291
	Group	-3.202	1.315	-0.273	-2.434	0.019	-5.851 -0.552
a. Dependent Variable: Posttreatment Personal Cost Score							

Figure 40. Coefficient list of posttreatment personal cost regression analysis.

As shown in Figure 40, some of the challenge variables can be used to significantly predict the posttreatment personal cost subscale score: Number of modes of transportation ($B = -2.462, p < .05$); Noise level ($B = 1.862, p < .05$); and, Lack of homework help ($B = -1.982, p < .01$). The negative correlation of the number of modes of transportation was unexpected, indicating that more modes of transportation would reduce the personal cost of doing mathematics. Lack of homework help was also negatively correlated, as expected, indicating that more homework help would bring down the personal cost and stress surrounding doing mathematics. The noise level being positively correlated was expected, indicating that higher noise levels increased the effort needed to do mathematics.

Being in the treatment group did make a significant contribution to the variance ($p < .02$) and so can be used to significantly predict the posttreatment personal cost subscale scores ($B = -3.202, p < .02$). The negative correlation of being in the treatment group meant that being in this group did help to bring down the personal cost subscale score indicating that it was less stressful doing mathematics. The 95% confidence interval for the group membership, -5.851 to -0.552 does not contain 0 so group membership does significantly predict the personal cost subscale score. Hypothesis H_{14} is therefore not rejected.

Review of the scatter plot between the regression equation prediction and the actual score shows many of the points tightly fitted around the fit line indicating a strong prediction ($R = .791, p < .01$), as shown in Figure 41.

Figure 41. Scatter plot of regression equation predicted scores and actual scores.

Analysis of Hypothesis H_2

Hypothesis H_2 posited that the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana would account for a significant amount of variance in predicting posttreatment achievement in algebra when controlling for sex, Challenges and prior mathematics achievement scores.

Sex was introduced into the model first, followed by the Grade 7 exam score, then the challenge scores and finally the study group indicator. Entry of sex into the model was not significant. However, addition of the prior mathematics achievement score accounted for a significant amount of variance ($R = .440, p < .001$) in predicting posttreatment achievement scores. Addition of the challenge variables also accounted for a significant amount of variance also ($R = .753, p < .02$) in predicting the posttreatment

mathematics achievement score. The teaching method also accounted for a significant amount of variance ($r = .784, p < .02$) as shown in Figure 42.

Model Summary ^e									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics F Change	df1	df2	Sig. F Change
1	.141 ^a	0.020	0.007	18.11985	0.020	1.525	1	75	0.221
2	.440 ^b	0.194	0.172	16.54380	0.174	15.971	1	74	0.000
3	.753 ^c	0.566	0.378	14.33852	0.372	2.167	21	53	0.012
4	.784 ^d	0.614	0.436	13.65634	0.048	6.427	1	52	0.014
a. Predictors: (Constant), Sex									
b. Predictors: (Constant), Sex, Grade 7 Exam									
c. Predictors: (Constant), Sex, Grade 7 Exam, People in Household, Parent school level, Distance from School, Electrical Outages, Sleepiness, Lack of Homework Help, Modes of Transportation, Living Arrangements, Lack of Family Encouragement, Frequency of Discouragement, Frequency of Missing Breakfast, No Convenient Study Area, Liming, Disturbance, No Adult home, Lack of Encouragement, Unable to study, Babysitting or Caring for Sick Relative, Frequency of Household Chores, Noise Level, Lack of Resources									
d. Predictors: (Constant), Sex, Grade 7 Exam, People in Household, Parent school level, Distance from School, Electrical Outages, Sleepiness, Lack of Homework Help, Modes of Transportation, Living Arrangements, Lack of Family Encouragement, Frequency of Discouragement, Frequency of Missing Breakfast, No Convenient Study Area, Liming, Disturbance, No Adult home, Lack of Encouragement, Unable to study, Babysitting or Caring for Sick Relative, Frequency of Household Chores, Noise Level, Lack of Resources, Group									
e. Dependent Variable: Grade 8 Exam									

Figure 42. Regression model summary for posttreatment achievement score.

Further analysis of the significant effects showed that the prior mathematics achievement score contributed 17.4% of the variance of the posttreatment achievement score over and above that contributed by sex, and can be used to significantly predict the posttreatment achievement score with $B = .519, p < .01$ as shown in Figure 43. The challenge variables contributed an additional 37.2% of the variance of the posttreatment achievement score and the teaching method accounted for an additional 4.8%.

Coefficients ^a							
Model	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	Sig.	95.0% Confidence Interval for B	
	<i>B</i>	Std. Error	Beta			Lower Bound	Upper Bound
1 (Constant)	31.116	2.763		11.261	0.000	25.611	36.621
Sex	-5.135	4.158	-0.141	-1.235	0.221	-13.419	3.149
2 (Constant)	3.346	7.393		0.453	0.652	-11.384	18.077
Sex	-1.581	3.899	-0.043	-0.406	0.686	-9.351	6.188
Grade 7 Exam	0.522	0.131	0.428	3.996	0.000	0.262	0.783
3 (Constant)	-8.050	10.255		-0.785	0.436	-28.618	12.519
Sex	-6.840	4.304	-0.188	-1.589	0.118	-15.472	1.793
Grade 7 Exam	0.447	0.127	0.366	3.506	0.001	0.191	0.702
Modes of Transportation	-6.276	3.262	-0.199	-1.924	0.060	-12.818	0.266
Distance from School	2.841	2.445	0.133	1.162	0.251	-2.064	7.745
Living Arrangements	-14.495	4.900	-0.318	-2.958	0.005	-24.323	-4.668
People in Household	6.199	1.956	0.343	3.169	0.003	2.275	10.123
Frequency of Missing Breakfast	-1.646	2.156	-0.090	-0.764	0.448	-5.971	2.678
Parent school level	2.536	1.989	0.141	1.275	0.208	-1.453	6.526
Lack of Family Encouragement	-2.527	3.509	-0.090	-0.720	0.475	-9.565	4.512
Lack of Encouragement	7.409	2.352	0.373	3.150	0.003	2.691	12.128
Frequency of Discouragement	0.623	2.491	0.030	0.250	0.804	-4.373	5.619
Unable to study	-3.338	2.472	-0.164	-1.350	0.183	-8.297	1.621
Noise Level	-0.997	2.377	-0.053	-0.419	0.677	-5.764	3.771
Disturbance	-0.307	2.675	-0.013	-0.115	0.909	-5.672	5.058
Babysitting or Caring for Sick Relative	-4.596	2.696	-0.219	-1.705	0.094	-10.004	0.812
Frequency of Household Chores	0.353	2.322	0.020	0.152	0.880	-4.304	5.009
No Adult home	3.063	2.150	0.161	1.425	0.160	-1.250	7.377
No Convenient Study Area	4.046	2.575	0.200	1.571	0.122	-1.118	9.211
Sleepiness	-1.198	2.702	-0.057	-0.443	0.659	-6.617	4.222
Lack of Homework Help	0.263	2.449	0.012	0.107	0.915	-4.650	5.176
Liming	-1.585	2.333	-0.075	-0.679	0.500	-6.264	3.094
Electrical Outages	-0.517	2.989	-0.017	-0.173	0.863	-6.513	5.479
Lack of Resources	-3.859	2.828	-0.184	-1.365	0.178	-9.531	1.813
4 (Constant)	-7.992	9.767		-0.818	0.417	-27.590	11.607
Sex	-3.822	4.268	-0.105	-0.896	0.375	-12.387	4.742

Coefficients ^a							
Model	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	Sig.	95.0% Confidence Interval for B	
	<i>B</i>	Std. Error	Beta			Lower Bound	Upper Bound
Grade 7 Exam	0.519	0.125	0.426	4.163	0.000	0.269	0.769
Modes of Transportation	-5.092	3.141	-0.161	-1.621	0.111	-11.396	1.212
Distance from School	2.372	2.336	0.111	1.015	0.315	-2.316	7.060
Living Arrangements	-13.347	4.688	-0.293	-2.847	0.006	-22.755	-3.938
People in Household	5.148	1.909	0.285	2.697	0.009	1.317	8.978
Frequency of Missing Breakfast	-0.997	2.069	-0.055	-0.482	0.632	-5.149	3.156
Parent school level	3.061	1.906	0.171	1.606	0.114	-0.763	6.885
Lack of Family Encouragement	-3.664	3.372	-0.130	-1.087	0.282	-10.431	3.102
Lack of Encouragement	7.832	2.247	0.395	3.486	0.001	3.324	12.340
Frequency of Discouragement	-0.220	2.396	-0.011	-0.092	0.927	-5.028	4.587
Unable to study	-2.325	2.388	-0.115	-0.974	0.335	-7.118	2.467
Noise Level	0.304	2.321	0.016	0.131	0.896	-4.354	4.961
Disturbance	-0.028	2.550	-0.001	-0.011	0.991	-5.145	5.089
Babysitting or Caring for Sick Relative	-3.810	2.587	-0.182	-1.473	0.147	-9.001	1.381
Frequency of Household Chores	0.403	2.211	0.023	0.182	0.856	-4.034	4.840
No Adult home	1.941	2.095	0.102	0.926	0.358	-2.263	6.146
No Convenient Study Area	1.448	2.658	0.071	0.545	0.588	-3.885	6.782
Sleepiness	-1.767	2.583	-0.084	-0.684	0.497	-6.950	3.417
Lack of Homework Help	-0.645	2.360	-0.029	-0.273	0.786	-5.382	4.091
Liming	-0.528	2.261	-0.025	-0.233	0.816	-5.064	4.008
Electrical Outages	0.037	2.856	0.001	0.013	0.990	-5.693	5.767
Lack of Resources	-2.451	2.750	-0.117	-0.891	0.377	-7.969	3.067
Group	-9.942	3.922	-0.273	-2.535	0.014	-17.812	-2.073

Figure 43. Coefficient list of posttreatment achievement regression analysis.

As shown in Figure 43, some of the challenge variables can be used to significantly predict the posttreatment achievement score. Living Arrangements showed a negative coefficient, *B*, of -13.347 ($p < .01$) indicating that living away from home

negatively impacts the student achievement. Number of People in the Household with coefficient, $B = 5.148$ ($p < .01$); indicated that the more people in the household, the higher was the achievement score. Lack of Encouragement from Others with coefficient, $B = 7.832$ ($p < .01$) also provided an unexpected outcome indicating that the less encouragement from those outside the family, the higher was the achievement score.

Not being in the treatment group did make a significant contribution to the variance as indicated by the negative coefficient, B , of -9.942 ($p < .02$) and so can be used to significantly predict the posttreatment achievement scores. Its negative correlation indicated that being in this group was not as beneficial as being in the control group. The 95% confidence interval for group membership, -17.812 to -2.073 does not contain 0 so group membership significantly predicts the achievement score. This hypothesis, H_2 , is therefore not rejected.

Review of the scatter plot between the regression equation prediction and the actual score showed many of the points fitted around the fit line indicating a fairly strong prediction ($r = .784$, $p < .02$) as shown in Figure 44.

Figure 44. Scatter plot of regression equation predicted scores versus actual post treatment achievement scores.

Analysis of Hypothesis H_3

Hypothesis H_3 posited that the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounted for a significant amount of variance in predicting posttreatment achievement in algebra over and above what is predicted by a difference in attitude scores towards mathematics when controlling for sex, challenges and prior mathematics achievement scores.

Sex was introduced into the model first, followed by the Grade 7 exam score, then the challenge scores. Next the difference in attitude scores was introduced and finally the study group indicator. Entry of sex into the model was not significant. However, addition of the prior mathematics score accounted for a significant amount of variance ($r = .440, p < .001$). Addition of the challenge variables also accounted for a significant

amount of variance also ($r = .767, p < .02$) in the posttreatment achievement score.

However, introduction of the difference in attitude scores did not contribute significantly to the variance of posttreatment achievement scores, nor did membership in the treatment group, as shown in Figure 45.

Model Summary ^f									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.063 ^a	0.004	-0.011	18.04805	0.004	0.268	1	68	0.607
2	.440 ^b	0.194	0.170	16.35978	0.190	15.759	1	67	0.000
3	.767 ^c	0.588	0.383	14.10516	0.395	2.101	21	46	0.018
4	.784 ^d	0.614	0.366	14.29514	0.026	0.696	4	42	0.599
5	.798 ^e	0.636	0.388	14.04351	0.022	2.519	1	41	0.120
a. Predictors: (Constant), Sex									
b. Predictors: (Constant), Sex, Grade 7 Exam									
c. Predictors: (Constant), Sex, Grade 7 Exam, People in Household, Electrical Outages, Frequency of Household Chores, Distance from School, Lack of Homework Help, Lack of Resources, Parent school level, Lack of Encouragement, Modes of Transportation, Living Arrangements, Noise Level, Frequency of Discouragement, Liming, Lack of Family Encouragement, No Adult home, Disturbance, Unable to study, Babysitting or Caring for Sick Relative, No Convenient Study Area, Frequency of Missing Breakfast, Sleepiness									
d. Predictors: (Constant), Sex, Grade 7 Exam, People in Household, Electrical Outages, Frequency of Household Chores, Distance from School, Lack of Homework Help, Lack of Resources, Parent school level, Lack of Encouragement, Modes of Transportation, Living Arrangements, Noise Level, Frequency of Discouragement, Liming, Lack of Family Encouragement, No Adult home, Disturbance, Unable to study, Babysitting or Caring for Sick Relative, No Convenient Study Area, Frequency of Missing Breakfast, Sleepiness, DiffAch, DiffUtil, DiffPersCost, DiffInt									
e. Predictors: (Constant), Sex, Grade 7 Exam, People in Household, Electrical Outages, Frequency of Household Chores, Distance from School, Lack of Homework Help, Lack of Resources, Parent school level, Lack of Encouragement, Modes of Transportation, Living Arrangements, Noise Level, Frequency of Discouragement, Liming, Lack of Family Encouragement, No Adult home, Disturbance, Unable to study, Babysitting or Caring for Sick Relative, No Convenient Study Area, Frequency of Missing Breakfast, Sleepiness, DiffAch, DiffUtil, DiffPersCost, DiffInt, Group									
f. Dependent Variable: Grade 8 Exam									

Figure 45. Regression model summary for achievement score after attitude scores.

Further analysis of the significant effects showed the prior mathematics achievement score contributed 19.0% of the variance of the posttreatment achievement score and can be used to significantly predict the posttreatment achievement score with $B = .466, p < .001$ as shown in Figure 46. The challenge variables also contributed 39.5% of the variance of the posttreatment achievement score and can be used to significantly

predict the posttreatment achievement scores after accounting for the variance consumed by sex and the prior mathematics achievement score. Although addition of the change in attitude scores accounted for 2.6% of the variance of posttreatment achievement scores, it was not considered to be significant. Likewise, being in the treatment group did not make a significant contribution to the variance and so cannot be used to significantly predict the posttreatment achievement score. This hypothesis, H_3 , is therefore rejected.

Coefficients ^a								
Model		Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	Sig.	95.0% Confidence Interval for B	
		<i>B</i>	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	29.366	2.854		10.291	0.000	23.672	35.061
	Sex	-2.255	4.359	-0.063	-0.517	0.607	-10.953	6.443
2	(Constant)	1.671	7.441		0.225	0.823	-13.181	16.522
	Sex	1.144	4.043	0.032	0.283	0.778	-6.926	9.214
	Grade 7 Exam	0.526	0.133	0.446	3.970	0.000	0.262	0.791
3	(Constant)	-13.108	11.883		-1.103	0.276	-37.028	10.811
	Sex	-4.602	4.467	-0.128	-1.030	0.308	-13.594	4.390
	Grade 7 Exam	0.466	0.135	0.395	3.453	0.001	0.194	0.738
	Modes of Transportation	-5.846	3.691	-0.182	-1.584	0.120	-13.276	1.585
	Distance from School	3.608	2.575	0.173	1.401	0.168	-1.576	8.791
	Living Arrangements	-14.649	5.160	-0.319	-2.839	0.007	-25.036	-4.262
	People in Household	6.861	2.110	0.383	3.251	0.002	2.613	11.109
	Frequency of Missing Breakfast	0.154	2.518	0.008	0.061	0.952	-4.914	5.221
	Parent school level	2.305	1.969	0.134	1.171	0.248	-1.657	6.268
	Lack of Family Encouragement	-2.662	3.674	-0.094	-0.725	0.472	-10.057	4.732
	Lack of Encouragement	5.990	2.505	0.305	2.391	0.021	0.948	11.032
	Frequency of Discouragement	1.319	2.629	0.065	0.502	0.618	-3.972	6.610
	Unable to study	-3.387	2.599	-0.165	-1.303	0.199	-8.619	1.844
	Noise Level	-0.261	2.423	-0.014	-0.108	0.915	-5.139	4.616
	Disturbance	-1.508	2.816	-0.066	-0.536	0.595	-7.177	4.161

Coefficients ^a								
Model		Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	Sig.	95.0% Confidence Interval for B	
		<i>B</i>	Std. Error	Beta			Lower Bound	Upper Bound
	Babysitting or Caring for Sick Relative	-4.783	2.843	-0.234	-1.682	0.099	-10.505	0.940
	Frequency of Household Chores	1.427	2.455	0.081	0.581	0.564	-3.515	6.368
	No Adult home	3.408	2.273	0.188	1.499	0.141	-1.167	7.983
	No Convenient Study Area	5.082	2.768	0.254	1.836	0.073	-0.489	10.652
	Sleepiness	-2.857	3.053	-0.136	-0.936	0.354	-9.002	3.289
	Lack of Homework Help	-1.072	2.762	-0.049	-0.388	0.700	-6.631	4.487
	Liming	-0.940	2.476	-0.046	-0.380	0.706	-5.924	4.044
	Electrical Outages	1.007	3.634	0.032	0.277	0.783	-6.308	8.322
	Lack of Resources	-3.610	3.787	-0.160	-0.953	0.345	-11.234	4.013

Figure 46. Truncated coefficient list of regression analysis of attitude change on achievement.

CHAPTER V

V. DISCUSSION

It was opening day of school. Students were in their shiny, new uniforms, exercise books well papered - one labeled Mathematics. I bravely stepped in and started to speak, only to realize that the walls did not go to the ceiling and there was no teacher next door so the students were catching up on the long August holidays. I could not hear myself speak so neither could the students in my class. One teacher described it as: “for the first few weeks, you get a headache from the noise and trying to speak above it.” By the time I had walked to the back of the class, repeating what I was saying to ensure they all heard, *YB* had left his seat and was walking around asking to borrow a pencil. Then *DD* was demanding back his ruler so that he could be sure he was writing his name in a straight line. *DC*, sitting in the front row, had his hands over his ears to keep out the noise, while *BB* just sat gazing into space. By the time *YB* was back in his seat and *DD* had found his ruler, the class had already forgotten what the discussion question was or where the lesson was going. Finally, *VH* asked: “why don’t you just tell us how to do it instead of asking all those questions?”

Over the next 11 weeks of the term, there was group work, skits, games, puzzles, pictures, relays, paintings, poetry, music, a Facebook group, videos, printed stories and instructions for them to derive concepts so we did not have to be talking over the noise. What was not finished in class, they had to finish at home – at least that was the intention. They did little homework, did not stop talking in class, and did not focus long enough to even understand what was written on the paper or understand the rules of the games. As one of the students wrote when I asked what they do not like about the classes: “children

in class always disturb the class.” Observers of the classes noted: “noise from passersby and neighboring classrooms”; “unnecessary in-class discussions”; “students were very loud when engaging fellow peers”; “students too loud when calling on the teacher”; “almost half the class not engaged in the activity, only when teacher calls on them”; “when teacher got students’ attention, session was very interactive”; “classroom got very disruptive”; “when group unattended, gave them more time to engage in other activities.”

Misconceptions abounded. After a lesson in which students saw that walking west then walking further west to model “ $-5 - 4$ ” provided a negative answer, *DF* had to say, as he ran from the classroom at the bell, “that is wrong, two negatives make a positive.” *JD* insisted that “ $-10 + 15$ ” had to be “ -5 ” because there was a negative sign at the beginning of the expression. Meanwhile *JOC* kept working out $-3(m + 2)$ as $-6m$ figuring he would just multiply everything and ignore the plus sign in between. Finally, he got the first step so he said, $6(3m + 5) = 18m + 30$, then he figured the answer had to be $48m$, ignoring that 30 was not being multiplied by m too. Many on the test when faced with $4 - 15 + 3$ determined they needed to calculate $15 + 3$ first because they had learned about *bodmas* – brackets, order, division, multiplication, addition, subtraction – and in this list addition appeared before subtraction.

Days without classes abounded too. During the Christmas term there were at least three national holidays, one parent-teacher association meeting, one parent visitation day, three house meetings, one teacher union meeting, four sports days and a week off for National Sports. Students would also arrange with their friends to come and say that a teacher wanted to see them, or they would ask to go to the bathroom and not come back.

Then there were the shining lights: those who begged to meet in the library where it was quieter; those who came for tutoring over lunch, during free periods or after school; and, those whose parents insisted that they do their homework. But, surprisingly, their focus shifted so quickly that they all found it hard to recall what was taught unless it was rehearsed several times over. For example, when *DB* turned to respond to who was calling him, he laid his handout face down on the desk. By the time he turned back, he could not find his handout (although it was in front of him on the desk, but facedown) and ended up asking for another one. Indeed, many factors were at play in introducing the students to a different way of learning.

Discussion of the Findings

SIS and Attitude Scales

Hypothesis H_1 posited that the use of subjectivist instructional strategies (SIS) in teaching multiple sections of an eighth grade algebra class in Guyana would account for a significant amount of variance in predicting posttreatment attitude scores towards mathematics, when controlling for sex, challenges and pre-treatment attitude scores.

Figure 47. Changes in attitudes towards mathematics over time.

Analysis of this hypothesis showed that for the experimental group, their interest in mathematics increased, they saw mathematics as being more useful, and it took less effort and anxiety to work with mathematics by the end of the term as shown in Figure 47. For the control group, their interest declined, they did see more usefulness for mathematics though not as much as the experimental group, they felt a greater need to do well in mathematics but this was at greater personal cost.

Most of the significant variance of the posttreatment interest scores was contributed by the challenges (44%) and less by the pretreatment interest score (13%). For the posttreatment utility score, most of the significant variance came from the pretreatment score (12.6%). The pretreatment need for achievement score was the only significant contributor to the variance of the posttreatment need for achievement score (26.1%). However for the variance of the posttreatment personal cost score, the highest significant contributor was the challenges (39.4%), followed by the pretreatment personal cost score (13.5%), then the use of subjectivist instructional strategies (4.9%). In all cases, though the pretreatment attitude scores contributed significantly, their contributions were dwarfed by the effects of the challenges.

Looking at how the challenges affected this outcome, as shown in Figure 34, living arrangements and lack of homework help were positively correlated with Interest. This indicates that those who were not living at home, or did not have as much help with homework, ended up more interested in mathematics. Indeed there were more students in the experimental group who were not living at home compared to the control group, and more in the experimental group were unable to find help with homework. It is possible that those not living at home were beginning to think independently and realize that they

needed to plan for the future, thus needed to get a better grounding in mathematics.

Those without much homework help in the experimental group may have been the ones attending the tutoring sessions thus having more opportunities to understand mathematics and get more comfortable with it.

No adults being home, no convenient study area, sleepiness and lack of family encouragement correlated negatively with the Interest scale. This indicates that those who had adults at home possibly insisting that they study, had a proper study area, were not so sleepy every night or had family encouraging them regularly developed a greater interest in mathematics. Indeed, there were more students in the experimental group receiving constant family encouragement, having a proper study area, not being so sleepy and having adults at home to see that they worked. In the Muola (2010) study, the correlation between family encouragement and motivation was low and not significant. However, the highest, significant correlations were found to be mother's education, family size and learning facilities at home. Muola (2010) interpreted these results as that in light of the favorable learning facilities, direct parental encouragement was less important or too pressuring. In the present study it seemed that the lack of parental encouragement was certainly of concern to students.

For the Personal Cost scale, the control group members reported more anxiety surrounding working mathematics problems whereas the experimental group reported less anxiety and less difficulty. Number of modes of transportation and lack of homework help were negatively correlated with this scale indicating that difficulty in getting to school and lack of help when needed served to increase the anxiety surrounding working mathematics. Difficulty in getting to school could mean reaching home later at

night or increased tiredness, allowing less time to study. More students in the experimental group had less homework help. However, as mentioned before, this may have helped them think about seeking tutoring, thus they became less apprehensive of mathematics.

Although more students in the experimental group had to do more travelling to get home, yet they seemed less anxious about mathematics. Thus some other factor was at play here in allaying fears where mathematics is concerned. Indeed, the teaching method was also found to be negatively correlated with the Personal Cost subscale score indicating that the tutoring and approach to learning mathematics in the experimental group served to lessen fears and anxiety in working with mathematics. This is borne out by the study done by Bentt (1971) where among 230 high school students in Guyana, 44% of the girls and 36% of the boys indicated that they liked mathematics, citing “good teaching” and relevant information as some of the reasons.

Benn (2009) in looking specifically at how students reacted to different teaching styles, found that although 48% of the students ended up below 50% of the passing score, they enjoyed themselves more and were still able to learn. For them, the personal cost of doing mathematics was reduced and they were able to recognize the difference in how it was taught. Nevertheless, as was observed in the present study, students are still hesitant to turn loose of old habits of expecting the teacher to explain everything instead of their having to develop concepts on their own (Pestano-Moonsammy, 2014). Once students start getting used to more involvement in their learning, then better longterm effects may unfold as was seen in the Mourning (2014) study that ran for two years.

SIS and Achievement

Hypothesis H_2 posited that the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana would account for a significant amount of variance in predicting posttreatment achievement in algebra when controlling for sex, Challenges and prior mathematics achievement scores.

Analysis of this hypothesis showed that the control group ended up at a significantly higher achievement score than the experimental group, though the group averages were both below 35%, as seen in Figure 48. For many of the students it took them about 20 minutes to get settled enough to start the test. Then those who finished first would immediately start making noise (even if they were outside the classroom) which served as a further distraction to those who had started late.

Test 1 was given during the sixth week of the term. Topics included adding and multiplying positive and negative numbers; using the Distributive Law with numbers only; degree of a polynomial; and converting word expressions to algebraic expressions. In Section 1 of the test were 5 required problems, then students could pick one of three questions from Section 2. With the exception of one question in Section 2, the questions were all procedural-oriented. The word problem in Section 2 was about forming an algebraic expression from a scenario. It was attempted by only students in the experimental group but few were able to give a complete answer.

Figure 48. Group achievement scores over time.

Test 2, given during the 10th week included: Simplifying algebraic expressions; Substitution; Indices; Binary operations; Solving simple equations by inspection; and, Basic factorization (reverse of Distributive Law). For this test, students had to fully understand working with variables and be able to manipulate them in expressions that included different signs, indices and brackets. They also had to understand the idea of raising an expression to the 0 power. This was the first time students were exposed to this much work with variables, so understandably, the scores dropped significantly from the first test. However, because of the extra holidays, no new teaching was done before the final exam which took place during the 14th week of the term and covered the same topics. Instead time was taken to review and go back over these topics. As can be seen, the final exam grades were significantly higher. The constant drill and practice taking place in the control group no doubt helped them to be able to follow the procedures faster, but, with having to show their work, there was still abundant evidence of lack of understanding in working with variables.

The major contributor to variance in achievement scores was the challenges (37.2%), then the prior mathematics achievement score (17.4%), followed by the use of subjectivist instructional strategies (4.8%). In the environment that obtained in the present study, there were several mediating influences on the teaching style: type of assessment; noise level; and, students' cultural expectations.

The effect of teaching style comes into play when the type of assessment is considered. For assessments that require only that one select the correct answer or show the correct steps, the practice-repetition teaching style employed by the teacher of the control group would seem to be more applicable. Indeed, the control group teacher had years of experience in not only setting the assessments, but also in training students to pass them. Additionally, the surrounding noise would be less of a challenge as examples and practice can be done on the board with minimal speaking.

On the other hand, the same teaching style (using SIS) that provided the students less anxiety and more enjoyment in working with mathematics also seemed to have affected their ability to retain concepts. Understandably, a teaching style that requires the use of mental skills espoused by Orhun (2013) is bound to falter amongst students who are too unfocused or unwilling to exert initiative. As more than one child wrote when asked about challenges that affect them: "Nothing really affects me, I just don't want to study"; "My mindset, I don't like to study"; "It's very boring."

Putting this together with the real challenges so many students faced such as living away from home, or being charged with household responsibilities, the lower pass rate becomes understandable. Girls, in particular, seemed caught in this, in that, in Guyana, they are expected to be caring for the younger ones or even doing more cleaning

than the boys (Jakson, 1985). Yet their attitude scores and achievement scores tended to be higher than the boys, but, like the Etwaroo (2011) study among 120 10th grade students in Guyana, the differences were not significant.

Culturally-based practices (McCloskey, 2014) can be hard to disrupt. After being trained from nursery in reproducing what the teacher shows and knowing they will be faced with procedurally-based assessments, students may lack the mindset to focus long enough to follow the train of thought all the way through. Over the years teachers revert to how they were taught (Pestano-Moonsammy, 2014) or may find it easier to control behavior when all the students are doing the same thing at the same time (Cothran, et al., 2005). Faced with traditional practices in all their other classes, students themselves may also not be willing to make the change to benefit from a different teaching style. As *DF* said when faced with seeing mathematics at work on a thermometer scale, “that’s not maths, that’s science.”

Effect of Attitudes on Achievement

Hypothesis H_3 posited that the use of subjectivist instructional strategies in teaching multiple sections of an eighth grade algebra class in Guyana accounted for a significant amount of variance in predicting posttreatment achievement in algebra over and above what is predicted by a difference in attitude scores towards mathematics when controlling for sex, challenges and prior mathematics achievement scores.

Students reported high attitude scores before and after treatment. For example, at the start of the treatment, 62% of the control group and 64% of the experimental group reported agreeing or strongly agreeing with the idea of finding mathematics interesting and its being fun to do mathematics. However, after the study, these numbers moved to

54% and 74% respectively. About seeing the usefulness of mathematics, 57% of the control group and 50% of the experimental group reported, pretreatment, agreeing or strongly agreeing that there were benefits to knowing mathematics and mathematics would be useful later in life. After the study, the control group report dropped slightly to 56% while the experimental group report soared to 70% agreeing or strongly agreeing. One would expect to see such attitudes contributing significantly to achievement and to raising achievement scores but research seems to present a mixed bag of results.

On the one hand, the Ministry of Education, Guyana (1980) found that attitude contributed significantly to achievement ($p < .01$) but average achievement scores were still below 50%. On the other hand, Aiken and Dreger (1961) found that attitude scores were significant predictors of achievement, but, only for women and not men. Skouras (2014) found no significant connection but found girls had less favorable attitudes yet higher achievement than the boys. Similarly, Etwaroo (2011) found that among Guyanese 10th graders, there was no correlation between attitude and achievement as 86% of the students showed high interest and utility outlooks yet it did not translate into their excelling at mathematics.

However, what is consistent is that high-achieving students also have high positive attitudes towards mathematics. Etwaroo (2011) found that among the students with excellent performance, 67% reported very positive attitude scores. Of those with good performance, 92% reported positive or very positive attitudes. Similarly, in the present study, those who achieved over 50% all reported low personal cost of doing mathematics, and agreeing or strongly agreeing on the interest in and usefulness of mathematics. Alternatively, whereas Etwaroo (2011) found that the low achievers

consistently reported low attitude scores, in the present study over 83% of those who received less than passing scores reported agreeing or strongly agreeing with mathematics being interesting and useful.

So, although the ending attitude scores were higher for the experimental group than the control group, the difference was not significant. Thus the teaching method did not have a significant effect where the attitudes were concerned. The effect of the challenge variables on the achievement has already been examined. That effect was still evident in analyzing the difference in attitude. Thus the change in attitudes towards mathematics was not significant enough to affect achievement nor was the change in teaching method. It would seem that the challenges were more daunting than a new approach to working with mathematics, or there is some other contributing factor, yet to be determined, that is more critical than attitudes.

Implications for Practice

Critical thinking seemed to be sadly lacking for these students. The lack of focus made it very difficult for them to follow through concept-building exercises. Easily bored, they became impatient with staying on a topic until they got all aspects of it. Groups could not always be put together optimally, so many times, the same group of easily distracted students ended up together.

Added to this was the effect of the challenges students faced at home and at school. These students come from high-academic backgrounds. Although some studies show that such academic parental influences help students stay in school and achieve higher (e.g., Williams et al., 2002), in the present study the high lack of adults at home to encourage studying may be caused by parents having to be out working to make ends

meet. Although certain situations at home cannot be remedied it may still be possible to provide support programs and accommodations at school that will compensate.

Though average skill levels were comparable between groups, the low achievement levels indicate the need for remedial help. Such a need exhibited itself when students could correctly apply algebraic principles then failed to multiply or add the numbers correctly. In the end, it seems the drill-and-kill won out, particularly, as the assessment instruments were composed of questions focused on applying procedures (see Appendix E) in alignment with national assessments.

Isik and Tarim (2009) discussed the need not only for student-centered teaching strategies, but also for students to be willing to participate in the learning process. Indeed, it would seem that one can take the horse to the water, but cannot make it drink. In the present study, although the students had high attitudes, and parents who seemed to be encouraging them to work, the students' approach can be summed up in *AB*'s farewell words: "Miss, we know we gave you a hard time, but we will miss you." Without the appropriate environment for learning and the inculcation into thinking through concepts, children who seemed to have what it took to excel, were content to do what was needed to attract attention as a cover for their lack of a proper foundation.

In the Isik and Tarim (2009) study, students in the experimental group achieved higher than the control group when cooperative learning groups that activated multiple intelligences were used. However, in the long term students' retention of mathematical concepts was no better than those in the control group. As was evidenced in the present study, the use of different teaching strategies needs to be started earlier and needs to be continued over a longer period of time.

Limitations of the Study

Students were not randomly assigned to treatment groups. However, homogeneity tests showed that the skill level and attitude levels of students in each study group were comparable. The number of students in each section as well as the number of students whose data were included in the final analysis also turned out to be comparable.

The study relied on students' completing two questionnaires. However, their lack of focus and issues with reading may have hindered the consistency of their responses. This was accommodated for by testing the reliability of the scores for this sample, then taking only the responses that were deemed to be the most reliable.

Since common tests were being used they needed to follow the established standard of being more procedural-based. Word problems were not included as all the sections had not received adequate exposure to that type of exercise.

A lot of valuable class time was lost with the many late class starts, holidays, rain days and other days off. An attempt was made to compensate for this by the researcher holding mathematics classes during free periods and offering assistance over school break. However, many of the students opted not to participate in these sessions.

Recommendations

On the basis of the present study, there are several areas that can be addressed if children in Guyana are to have any hope of excelling in mathematics:

1. Provide a low-noise environment that is conducive to mental activity and discussion.
2. Schedule activities such that time and focus are not taken away from much-needed class time.

3. Start encouraging children from the earliest grades to discuss and formulate concepts as a regular approach to learning. Orhun (2013) speaks of the need for a teaching method that “drives them [students] to use their mental skills in order to find fresh information by themselves” (p. 1164).
4. Foster a culture of achievement. *DW* was hesitant to come for tutoring lest he got smarter than his friends and they shunned him. Inculcate children into the idea of taking the responsibility to care enough to excel and being willing to make the effort to succeed.
5. Proactively address after-school challenges. For example, those who do not have appropriate study areas at home may be happy to stay after school to use study facilities there. Such a study facility would provide access to textbooks and other appropriate study materials.
6. Plan for how students can receive remedial help. Many students were losing points on work that should have been mastered in lower grades.
7. Provide national assessments that do not rely on “teaching-to-the-test” or “drill-and-kill”. More applications should be included instead of just testing number-crunching or re-hashing procedures.
8. Provide more help professionally and materially for teachers to encourage them to explore different strategies.

More research is needed to document how students respond once the environment is more conducive to thinking. The degree to which students formulate concepts by exploration needs to be measured more closely instead of just looking at how they apply

the concepts on a test. A partnership is also needed, a commitment even, between teachers, parents, children and the Ministry of Education, to step away from rote teaching, to encourage a culture of critical thinking, and, to start challenging our children from their very first days of learning.

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APPENDICES

Appendix A

Original Mathematics Value Inventory

Mathematics Value Inventory. Source: Luttrell, V. R., Callen, B. W., Allen, C. S., Wood, M. D., Deeds, D. G., & Richard, D. C. S. (2010). Mathematics Value Inventory [Database record]. Retrieved from PsycTESTS. doi: 10.1037/t05789-000

Items
I. Interest I find many topics in mathematics to be interesting. (12) Solving math problems is interesting for me. (24) Mathematics fascinates me. (27) I am interested in doing math problems. (20) It is fun to do math. (16) Learning new topics in mathematics is interesting. (2) I find math intellectually stimulating. (9)
II. General Utility There are almost no benefits from knowing mathematics. (3r) I see no point in being able to do math. (17r) Having a solid background in mathematics is worthless. (13r) I have little to gain by learning how to do math. (6r) After I graduate, an understanding of math will be useless to me. (10r) I do not need math in my everyday life. (23r) Understanding math has many benefits for me. (21)
III. Need for High Achievement Earning high grades in math is important to me. (19) It is important to me to get top grades in my math classes. (8) If I do not receive an "A" on a math exam, I am disappointed. (4) Only a course grade of "A" in math is acceptable to me. (25) I must do well in my math classes. (28) I would be upset to be just an "average student" in math. (11) Doing well in math courses is important to me. (14)
IV. Personal Cost Math exams scare me. (26r) Trying to do math causes me a lot of anxiety. (22r) Taking math classes scares me. (5r) I worry about getting low grades in my math courses. (7r) I have to study much harder for math than for other courses. (1r) Mathematical symbols confuse me. (15r) Solving math problems is too difficult for me. (18r)
Note: Item numbers are in parentheses following item content. Lowercase "r" indicates reverse-scored item.

Appendix B

Modified Mathematics Value Inventory

Interest

- 12. I find many topics in mathematics to be interesting.
- 24. Solving math problems is interesting for me.
- 27. Mathematics is real interesting to me. (m)
- 20. I am interested in doing math problems.
- 16. It is fun to do math.
- 2. Learning new topics in mathematics is interesting.
- 9. I find math makes me think. (m)

General Utility

- 3. There are almost no benefits from knowing mathematics. (r)
- 17. I see no point in being able to do math. (r)
- 13. Having a solid background in mathematics is not useful. (r) (m)
- 6. I have little to gain by learning how to do math. (r)
- 10. After I leave high school, an understanding of math will be no use to me. (r) (m)
- 23. I do not need math in my everyday life. (r)
- 21. Understanding math has many benefits for me.

Need for High Achievement

- 19. Earning high grades in math is important to me.
- 8. It is important to me to get top grades in my math classes.
- 4. If I do not receive an "A" on a math exam, I am disappointed.
- 25. Only a course grade of "A" in math is acceptable to me.
- 28. I must do well in my math classes.
- 11. I would be upset to be just an "average student" in math.
- 14. Doing well in math courses is important to me.

Personal Cost

- 26. Math exams scare me. (r)
- 22. Trying to do math causes me a lot of stress. (r) (m)
- 5. Taking math classes scares me. (r)
- 7. I worry about getting low grades in my math courses. (r)
- 1. I have to study much harder for math than for other courses. (r)
- 15. Mathematical symbols confuse me. (r)
- 18. Solving math problems is too difficult for me. (r)

Note: Lowercase (r) following an item indicates reverse-scored item.
Lowercase (m) following an item indicates a wording modification.

Appendix C

Observation Survey

Mathematics Classroom Observation

Based on: Gleason, J., Livers, S.D., & Zelkowski, J. (2015). Mathematics classroom observation protocol for practices: Descriptors manual. Retrieved from <http://jgleason.people.ua.edu/mcop2.html>

Reviewer: _____

Date: _____

Class: _____

Time: _____

Topic: _____

1 Learning a new concept

- ☐ Students were guided in determining the concept
- ☐ Teacher just gave the rules
- ☐ No new concept being taught

2 Representing concepts (Mark all that apply)

- ☐ List of rules
- ☐ Drawings e.g. the number line
- ☐ Story
- ☐ Real-life application
- ☐ Manipulatives

3 For most of the lesson, students were:

- ☐ Listening and taking notes
- ☐ Working on mathematical problems

4 Solving problems

- ☐ Students had to use at least 2 ways then determine which way was better
- ☐ Students were expected to use just one method.

5 When students had to work problems:

- ☐ Most immediately said they did not understand
- ☐ Most reviewed carefully then asked questions
- ☐ Most tried to work them but got distracted or gave up
- ☐ Most stuck with the problem until it was solved

6 Working problems

- ☐ Students had to show working
- ☐ Students had to explain why they were working it that way
- ☐ Students were expected to just write the answer

7 Application of lesson to real life

- ☐ Real-life application used in deriving concept
- ☐ Exercises involved real-life scenarios
- ☐ No mention of real-life situations.

8 Analysis while learning (Mark all that apply)

- ☐ Students had to give conjectures
- ☐ Students had to look for patterns
- ☐ Students made generalizations
- ☐ None of the above

9 Types of problems used (Mark all that apply)

- ☐ Have multiple solutions
- ☐ Can be solved using different strategies
- ☐ Emphasis is on arriving at one answer using one strategy
- ☐ Students are discouraged from exploring additional solutions.

Appendix D

The Challenge Index Survey

Name: _____

Grade: _____

As part of a research project into improving students' grades in mathematics, we are trying to determine the issues students face as they attend school each day. We are therefore seeking your help in identifying these issues. Your answers are confidential so please answer each question as truthfully as possible.

As you answer the questions below, think about your time now in 8th grade.

1	Are you a boy or a girl?	Boy	Girl						
2	Give the name of the city, town or village where you live on school days.								
3	Think of how you travel to school on one particular day. Mark all the types of transportation you use on that day.	Walk	Bicycle	Private Car	Taxi or Hire car	School Bus	Speed Boat	Ferry	Mini-bus
4	Are you living at home on school days or staying with someone else?	Living at Home	Living with extended family		Living with someone else				
5	About how many people live in the same household with you?								
6	How often do you eat breakfast before coming to school?	Never	Once in a while	Many Times	Every day				
7	Think of one older female in your household who went to school. What level of schooling did this person complete?	Primary School	Secondary School	High School	College	University	Vocational School	None	
8	What relation is this female person to you?								
9	Think of one older male in your household who went to school. What level of schooling did this person complete?	Primary School	Secondary School	High School	College	University	Vocational School	None	
10	What relation is this male person to you?								
11	How often does your family encourage you to do well in mathematics?	Never	Once in a while	Many Times	Every day				
12	How often do other students or your friends encourage you to do well in mathematics?	Never	Once in a while	Many Times	Every day				
13	How often does someone discourage you from doing well in school?	Never	Once in a while	Many Times	Every day				
14	How often are you able to study after school, if you want to study?	Never	Once in a while	Many Times	Every day				
15	Please circle how often each of the following situations affects how much you are able to study when you want to:								
	Too much noise	Never	Once in a while	Many Times	Every day				
	Disturbances or stuff happening at home	Never	Once in a while	Many Times	Every day				
	Babysitting the younger ones or Taking care of a sick family member	Never	Once in a while	Many Times	Every day				
	Housework	Never	Once in a while	Many Times	Every day				
	Adults not home	Never	Once in a while	Many Times	Every day				
	No comfortable place to study	Never	Once in a while	Many Times	Every day				
	Too sleepy or tired	Never	Once in a while	Many Times	Every day				
	No one to study with or help me with school work	Never	Once in a while	Many Times	Every day				
	Liming with friends or social media	Never	Once in a while	Many Times	Every day				
	Blackouts (no electricity)	Never	Once in a while	Many Times	Every day				
	No textbooks or study resources	Never	Once in a while	Many Times	Every day				
16	Please describe one or two things (not mentioned before), if any, that affect how much you are able to study, if you want to study:								

Thank you for your participation.

Appendix E

End of Term Examination

<p>Section One: Answer all questions by circling the letter of the correct answer. Each question is worth 2 marks.</p> <ol style="list-style-type: none"> 1. If $a = 2$, $b = 3$ and $c = 5$ what is the value of $4a + 3b + 2c$? <ol style="list-style-type: none"> (a) 25 (b) 27 (c) 26 (d) 19 2. Simplify the expression $4y - 6y + 7y$ <ol style="list-style-type: none"> (a) $17y$ (b) $5y$ (c) $-8y$ (d) $140y$ 3. What is the exact value of $(4a \times 5a)^0$ <ol style="list-style-type: none"> (a) 0 (b) 1 (c) 20 (d) $20a^2$ 4. Simplify the expression $3p^2 \times 4p^3 \times 2p$ <ol style="list-style-type: none"> (a) $9p^3$ (b) $12p^6$ (c) $24p^5$ (d) $24p^6$ 5. Simplify $m^9 \div m^6$ <ol style="list-style-type: none"> (a) m^{-3} (b) m^3 (c) $2m^{15}$ (d) m^{15} 	<p>Section Two: Select and answer 4 questions from this section. Each question is worth 5 marks. Show ALL your working.</p> <ol style="list-style-type: none"> 1. Simplify: $5y + 7(4y - 3)$ 2. State the degree of the polynomial: $ap + a^4p^3 + a^2p^6$ 3. Factorize: $12w - 2wz$ 4. Simplify: $\frac{y^5ab}{y^3a}$ 5. Simplify: $\frac{h}{3} + \frac{5h}{6}$ 6. Given that $m \triangle n$ means $m^2 + 2mn + n^3$ calculate $3 \triangle 2$ 7. Simplify: $\frac{h}{3} \times \frac{5h}{6}$ 8. Solve for p: $6p + 2 = 26$
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VITA

JENNIFER HOYTE

1974 – 1977	High School Teacher	St. Rose's High School North Georgetown High School Georgetown, Guyana
1979	Grace Bareis Memorial Scholarship B.Sc. Mathematics and Computer and Information Science with Distinction in Computer Science Undergraduate thesis: "The Generation of the Input Space of a Computer Program" Member: Software Engineering Research Group OSU student chapter of the Association for Computing Machinery	The Ohio State University
1980	M.Sc. Computer and Information Science Graduate Teaching Associate	The Ohio State University The Ohio State University
1981 – 1986	Researcher Scientist	Battelle Memorial Institute Columbus, OH
1986 – 1993	Software Development Manager	Information Dimensions, Inc. Dublin, OH
1994 – 1996	Director, Systems & Programming	City of Hollywood Hollywood, FL
2002 – 2009	Adjunct Professor	Palm Beach Atlantic University, FL South University, FL Keiser University, FL
2009 – present	Doctoral Candidate Dissertation: How the Use of Subjectivist Instructional Strategies in Teaching Multiple Sections of an Eighth Grade Algebra Class in Guyana Relates to Algebra Achievement and Attitude Changes Towards Mathematics	Florida International University
2009 – 2011	Presidential Fellow Golden Key International Honour Society	Florida International University
2012	Reviewer - <i>Proceedings of the 11th Annual College of Education & Graduate Student Network Research Conference - 2012</i>	
2012 –	Judge	Miami-Dade STEM Expo

2014	Adjunct Professor	Florida International University
2012 – Present	Editorial Review Panel Journal of International Students	Arkansas State University
2015	US Fulbright Scholar to University of Guyana Reviewer - AERA 2015 Annual Meeting	

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