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The relationship between cooperative learning and physics achievement in minority students

Victor Chester
Walden University

Walden University

COLLEGE OF EDUCATION

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Victor Chester

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the review committee have been made.

Review Committee
Dr. Ina Delahoussaye, Committee Chairperson, Education Faculty
Dr. Pamela Warrick, Committee Member, Education Faculty

Chief Academic Officer

Denise DeZolt, Ph.D.

Walden University
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ABSTRACT

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by

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Doctoral Study Submitted in Partial Fulfillment

of the Requirement for the Degree of

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Minority students lag Caucasian students in science performance and are underrepresented in the fields of science and technology. It is therefore pivotal for minorities, African American and Hispanic students, to show improved performance in science education. The purpose of this study was to investigate the impact of cooperative learning strategy on physics achievement by high school minority students. Constructivism formed the theoretical framework for the study. Independent learning, the traditional strategy, and cooperative learning dyads, the novel intervention, were the independent variables, and the dependent variable was achievement in physics. A repeated measures design and a convenient sample group of students were used in this study. Difference of scores obtained from the performances of the group as independent and cooperative learners was subjected to a repeated measures t test. A significant relationship between cooperative learning dyads and physics achievement by high school minority students was found. By learning in small groups, students were able to help each other construct meaning and make sense of their learning. Further study was recommended to foster cooperative learning strategy in minority classes and among science teachers of high schools with a majority of minorities. Social change is embedded in the study as increased achievement in science by minority students could possibly lead to advancement in science and technology careers for minorities and possibly close the gap that exists in science performance between minority and Caucasian students. This change could lead to a better social status for minorities.

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SECTION 1: INTRODUCTION TO THE STUDY

Introduction

The success of any nation will follow the successful achievement of all of its peoples (Hargreaves, 2003). This opening statement is better understood when Hargreaves stated, “All children must be properly prepared for the knowledge society and its economy” (p. 21). Lambert, Walker, Zimmerman, Cooper, Lambert, Gardner, and Szabo (2002), alluded that nearly two hundred years have passed and the United States has yet to “accomplish this seminal goal of equity” (p. 33) in ensuring an equal education for all of its children.

There is some evidence (Hargreaves, 2003; Lambert et. al., 2002) that a nation that sets out to succeed in the current global economy must consider education for all of its children, which, included minority (all non-Caucasian Americans) children. There seems to have been an oversight of this issue in the nation because minority children seem to have been at a disadvantage throughout the history of the nation (Lambert et. al., 2002). To leave out a sector of the nation’s academic resource whether it was a question of social-economic status, ethnicity, or due to level of performance, could not adequately cater for full production and preparedness. The nation will become deficient in meeting global competitiveness (Hargreaves, 2003) and places it in a very vulnerable position. It therefore becomes incumbent on all educators for all children to be included, regardless of social, economic, ethnic, cognitive or otherwise, in a national plan for reforming education. Such a plan must include adequate funding for broad based structural changes in the academic goals and curricula throughout the nation.

The demographics have changed in schools because the number of minority students in American schools has shown a steady increase in the schools of the nation (Allsion & Rehm, 2007; Goldenberg, 2008). Although minorities have dominated the school system within the nation, there is much to be desired in the area of achievement (Dantely, 2004; Stern, 2004). A 2005 policy alert reported that minorities are less educated than non-minorities and are subsequently paid less in their jobs. It is important, then, that minority children be given attention to change this current social trend.

The importance for minorities to improve their performance in standardized exams was addressed by Sleeter (2008) in an invitation addressed to the 44^{th} President of the nation. Sleeter (2008) called for more funding to produce more qualified teachers who meet the needs of today's schools with a diverse population. This educator recognized the need for urgent social action which must be initiated from the schools. School reform was thereby anticipated that could foster social improvement among minorities. Improvement in the quality of life for all people in the nation was seen as a must for national and global survival.

School reform has been constantly going on in the school system and the need for greater achievement has always been a desired goal. However, there appears to be a shift in focus from achievement in general to achievement by minorities. There was a definite call for greater achievement by minorities in the area of science (Dantely, 2004; Hoffer, Rasinski & Moore 1995; Simmons, 1993). Nealy (2007) and Clarke (1999) have also noticed how minorities are underrepresented in the fields of science and technology.

These changing demographics in the schools across the nation (Allison & Rehm, 2008; Gandara, 2007; Goldenberg, 2008), following with low achievement by minorities in science (Dantely, 2004; Hoffer, Rasinski & Moore, 1995; Simmons, 1993) requires change in the instructional strategies of science teachers to bring about the necessary change in achievement by minority science students (Dantley, 2004; Madrid, Canas & Ortega-Medina, 2007). Instructional change or adjustment precedes change in academic performance (Dantley, 2004; Padron, Waxman, & Rivera, 2002) and ultimately social change. Many have dwell on the point on how poorly minorities are performing in science and altogether academically (Dantley, 2004; Hoffer, Rasinski, & Moore, 1995; Simmons, 1993). The poor achievement of minority students has brought about a variety of ideas about how to improve their academic scores in science. One of those approaches involves the use of cooperative learning, defined as learning together in small groups (Cohen, 1994) This study will investigate the relationship between achievement by minority physics students and cooperative learning.

Although cooperative learning (learning together in small groups) has been around for decades now, there has been a recent shift towards greater emphasis on this learning strategy by both K–12 schools and universities (Attle & Baker, 2007; Bevevino & Snodgrass, 1998; Bollag, 2007; Madrid, Canas & Ortega-Medina; 2007). Several studies have been done that showed that this learning strategy was effective (Fredericksen, 1998; Fuller, 2001; Liu, 2005; Madrid, Canas & Ortega-Medina, 2007; Ochoa & Robinson, 2005; Novemsky, 2003;Tao, 2000) and therefore became a relevant strategy to be implemented in teaching science for possible higher achievement by minority science students.

For example, Bell, Clark, Gebo and Lord (1989) pointed out the need for the school systems to reflect real world work environments. They observed that in the real world people work cooperatively and that "90 percent of all human interaction is cooperative" (p. 116). Also, Bevevino and Snodgrass (1998) have agreed that many teachers are today accepting research results which have indicated that cooperative learning is an effective instructional strategy. As a result they believe that "many administrators want their teachers to incorporate" (p. 65) cooperative learning in their instruction.

Fredericksen (1998) worked with El Paso University in Texas which has a majority of Hispanics in that state, 66%, and found that these students learn better in clusters and learning communities. Ochoa and Robinson (2005) have also indicated how "students learn more in groups than in lecture" (p.3). Here, it was certainly documented that cooperative learning does positively influence achievement.

Problem Statement

The performance of minorities in science and mathematics leaves much to be desired. Studies have shown low performance in these key areas of science and mathematics, (Dantely, 2004; Hoffer, Rasinski & Moore, 1995; Simmons, 1993; Stern, 2004) which places Hispanics and African Americans at the lower end of the performing scale.

The nation's report card (2005) showed African American and Hispanic students performing below Caucasians in science. Compared to 1996, the report card for 12th graders showed no change in performance in science for these students in 2000 and for 2005, there has been a decline in performance.

Dantley (2004) deplored the poor performances in science by minorities and blamed it on the lack of qualified science teachers in the system. Dantley stressed how it was imperative for teachers to adjust their teaching practices in order for the No Child Left Behind (NCLB) goal to be achieved by 2013-2014.

Simmons (1993) alluded to the need for minorities to raise their performance if the national goals are to be reached. Simmons also pointed out that even though African Americans and Hispanics were showing signs of increased performance, they were still lagging behind Caucasians by 20-40 points in science, mathematics, reading and writing.

Hoffer, Rasinski, and Moore (1995) also highlighted this lag in performance of African Americans and Hispanics behind Caucasians. These authors indicated a correlation between the number of courses a student took and achievement. It was found that minorities took fewer science courses than Caucasians and Asians and correspondingly performed poorer than Caucasians and Asians.

Minority children form a significant portion of the nation and are quickly becoming the majority in the nation’s schools. Regardless of their percentage within the nation all children must be considered in any economy for that nation to be globally competitive (Hargreaves, 2003) as well as they should all be included in a national educational plan (Barth, 2001).

Although statistics showed minorities to be increasing in numbers, it is important that this fact be considered when planning for the overall educational progress of the nation because leaving minorities out of the equation could have dire social and economic consequences (Friedman, 2009). Already, this lagging in performance by minorities behind Caucasians, is not good for the nation and therefore, cannot be allowed to continue (Clark, 1999; Goldenberg, 2008; Nealy, 2007; Sleeter, 2008).

Sleeter (2008) underscored the importance of teachers who can address the needs of minorities. A need for better trained teachers who can deal with diversity has been identified. Also, Nealy (2007) and Clark (1999) have identified minorities as underrepresented in the fields of science and technology. This under representation in these high paying fields will be reflected in the job titles associated with minorities (Gandara, 2008). More significantly, Allison and Rehm (2008) and Goldenberg (2008) have also recognized the growing population of minorities in the school system and this could ultimately lead to severe social and economic consequences (Friedman, 2009; Hargreaves, 2003) if the status quo on minority performance (Gandara, 2008; Nation's report card, 2005) in the school system was allowed to continue.

With the minority population of students on the increase, the poor paying jobs occupied by minorities, the under representation of minorities in the fields of science and technology and the poor performances by minorities in science education, educators in the country must urgently find more effective ways of instructing minority children in science. This problem among minority students can be identified as one relating to achievement. The big educational implication then that followed was how educators could solve this problem.

A positive relationship has been found between cooperative learning and achievement (Munoz & Clavijo, 2000; Krajcik, Marx, Blumenfeld, Soloway & Fishman, 2000; Saleh, Lazonder & De Jong (2005); Tao, 2000). The increase in achievement has been attributed to the social interaction and collaboration of this learning approach. From this reasoning, the current study will employ cooperative learning as an intervention to assess its impact on physics achievement for high school minority students.

The Nature of the Study

This study was quantitative with a repeated measures design. The study investigated the impact of cooperative learning dyads on physics achievement by minority students. Students were exposed to two different learning strategies: independent learning and cooperative learning. One physics class was comprised of students who scored similarly well in science or math. By being similar meant that the students were either high achiever in math or science or in both. Students also had a high overall average. The students completed most of the syllabus when data collection was done. Students were in the class from the beginning of the term (in September), and were taught how to learn cooperatively. Students were told that this form of learning consisted of sharing techniques and skills and working together in small groups (dyads) to solve problems (Johnson & Johnson, 1999; Novemsky, 2003). They were also told that besides developing good academic skills they would have developed good social skills as well (Tao, 2000) which they used to help them academically. Through this method of learning they developed trust for each other and thereby their confidence in learning was being strengthened (Dwyer, 2002). Students were instructed how to help each other learn and develop a good physics vocabulary (Marzano, 2003). They also learned how to help each other in understanding physics concepts by helping one another in contextualizing vocabulary and identifying everyday applications of the concepts commensurate with their experiences (Finkelstein, 2005; Park & Lee, 2004; Lye, Fry & Hart, 2002; Wilkinson, 1999). Lessons and homework were designed to foster cooperative learning and avoid cheating or one student depending solely on the other for the answers (Johnson & Johnson, 1999). Tests were given independently so that students learned the importance of authentic learning. This orientation took place for the entire first semester during the course of the regular teaching periods and continued into the second semester until the end of the school year.

When students are not randomly selected for an experiment the sample is deemed one of convenience (Creswell, 2003) or stratified randomly selected when the sample is manipulated conveniently (Creswell, 2003; Johnson & Johnson, 1999). Analysis of performance by the group on standardized state examination questions measured achievement by high school physics students. More details on this are found in section 3.

Research Questions and Hypotheses

The main question in this study is: What is the impact of a cooperative learning teaching strategy on physics achievement by high school minority physics students?

The null hypothesis is: There is no significant relationship between cooperative learning teaching strategy and physics achievement by high school minority students.

The alternative hypothesis is: There is a significant relationship between cooperative learning teaching strategy and physics achievement by high school minority physics students.

Purpose of This Study

The purpose of this study was to investigate the impact on learning style (either cooperative learning or independent learning) on physics achievement by high school minority students. A relationship has been found between cooperative learning and achievement (Allison & Rehm, 2007; Ochoa & Robinson, 2005); this relationship has been found in minority samples (Fredericksen, 1998; Madrid, Canas, & Ortega-Medina, 2007; Morgan, 2004) and among physics students (Ding, & Harskamp, 2006; Krajcik et al., 2000; Munoz & Clavijo, 2000; Saab, Joolingen & Hout-Wolters, 2006; Saleh et al., 2000; Tao, 2004; Tao, 2000).

Theoretical Base of the Study

This study is guided by the theory of constructivism, which supports the idea of constructing meaning and new knowledge through expert teaching (Lambert et al., 2002).In this study cooperative learning is seen as a vehicle for utilizing language and culture to foster the construction of meaning and new knowledge. By this means of learning, students' development of knowledge by when they connect previous knowledge to new constructs and develop new understandings resulting in learning. This theory of constructivism has been connected to previous theories by Dewey (1938), Bruner (1987), Piaget, and Vygotsky (Lambert et al., 2002).

This study is also based on the basis models of learning of which cooperative learning is one of the proposed models (Oser & Baeriswyl, 2001). The basis models of learning focus on how children construct meaning or how they learn. Oser and Baeriswyl view learning as an internal phenomenon, and teaching, as a visible structure. By internal, these authors meant what takes place inside the minds or heads of the learners and by visible structure they referred to what the students see the teacher presents. It is purported that if teachers understand how children learn then they can enhance learning by presenting the visible structure or, instructional strategy, in such a manner that the correct cognitive operations within the mind of the learner will take place and thus resulting in authentic learning. Authentic learning is seen here as constructing the correct knowledge internally. Oser and Baeriswyl, recognize cooperative learning as one such model or, visible structure, that can be used to effect the right cognitive operations which may result in authentic learning.

Ethnography studies also indicate the need for minority students to learn in a manner commensurate with their cultural background (Battistich, Solomon, Kim, Watson & Schaps, 1995; Zeuli & Floden, 1987). Battistich et al., (1995) did a study on community learning and found that minority students excel in a number of ways including academic performance. Their study indicates that students learning in a community setting (which includes cooperative learning) provide support and motivation for the students. Watson and Schaps (1987) stressed the need for classroom settings to be "culturally congruent" (pp. 9-11). They also show how this form of teaching practice significantly improved learning among diverse cultures and minority classrooms. Hence the decision to use cooperative learning as a possible instructional intervention to effect achievement among minorities learning physics. Studies pertaining to this theoretical base will be analyzed in detail in Section 2.

Operational Definitions

The following terms are defined using definitions from other educators and researchers: *Achievement, authentic learning, cooperative learning, collaborative learning, constructivism, independent learning, minorities, and dyads*.

Achievement: By achievement is meant how students will perform in the tests given to them after exposure to independent and cooperative learning in solving physics problems.

Authentic learning: "provide learners with the motivation to construct knowledge and enabling them to apply such understanding to problems" (Endelson, Gordin & Pea, 1999).

Collaborative learning: "… an umbrella term for a variety of educational approaches involving joint intellectual efforts by students, or students and teachers working together …" (Smith & MacGregor, 1992, p. 1).

Cooperative learning: a learning style where students work together in a small group, and where, everyone can participate on a collective task (Cohen, 1994).

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Constructivism: "It recognizes the construction of new understanding as a combination of prior learning, new information, and readiness to learn" (Vico, 1995, p. 2).

Dyad: A dyad is defined as a pair of students of mixed ability in which one student performs better than the other one in physics standardized tests.

Independent Learning: By independent learning is meant when students are not encouraged to discuss questions or problems before arriving at a solution. They must think on their own

Minorities: Minorities in this study refer to all students who are Afican Americans, Asians, Hispanics, students from the Mid-East, African and Indo- Caribbean, others who are not Caucasians.

Assumptions

One assumption from this study was that any change in physics achievement was due to the independent variable, cooperative learning dyads, and no other extraneous variable, such as gender, ethnicity, ability, or, experience. Another assumption was that language barriers were not a problem for participating students and they were able to understand the physics assessment administered to them.

Limitations and Delimitations

This study was limited to 32 minority students, enrolled in physics classes, in a city high school. This small sample may have impacted the validity of the results. The minimum number of participants required to make a sample valid is 30 (Gravetter & Wallnau, 2005). Therefore a greater sample tends to produce a better chance of more reliable results.

Since the group only consisted of 32 students, a decision was made in favor of a repeated measures design instead of splitting the group into two subgroups. This would have produced a control and an experimental group but the limited number of students could not have allowed for this set up.

Another issue avoided in this study was the inclusion of Asian students. Although Asian students are generally considered to be of a higher performing ability, this factor was not necessarily true for this sample of students. For the most part, these students needed the same help like any of the other students in the sample.

Significance of the Study

Constructivism espouses the use of social skills, dialogue, to enhance the construction of meaning and new knowledge and cooperative learning is identified as an essential teaching strategy of accomplishing this task (Bruner, 1987; Dewey, 1938; Lambert et al., 2002). Physics contains vocabulary that could be strange and difficult to comprehend (Novemsky, 2003). When students learn physics by solving problems in dyads a comfortable atmosphere and a feeling of trust can be created (Dwyer, 2002) which can sustain a condition favorable to learning.

Minorities are of varying background due to ethnicity and country of origin thereby creating experiences very incongruent to a physics background. This incongruence leads to difficulty in comprehending physics. Learning to solve physics problems using cooperative learning strategy can be of great help to the learning process. NCLB also requires all children to be considered in the learning process and Barth (2001) calls for all children to be included in an educator's plan for the success of all children. Therefore, lack of participation or comprehension due to little or no experience with certain scenarios in physics should not be considered fair and therefore deprive a child of learning physics. By using cooperative learning dyads, such impediments to learning could be overcome by having a more experienced learner help to translate such experiences and make the learning experiences more meaningful and comprehensible through dialogue.

Students were expected to critically analyze each other's solutions to a problem. They probed into why the other learner had decided on a different equation or identified a different concept. By critiquing each other's solution it was expected that understanding would be developed and meaning would become clearer. It was in this context of cooperative learning that learning physics was expected to promote easier comprehension of the subject.

This study also holds for social significance because minorities are underrepresented in the fields of science and technology (Nealy, 2007; Clark, 1999) and because the success of all children in society is pertinent to a successful nation (Hargreaves, 2003). Social capital is necessary for the growth and development of a knowledge society (Hargreaves, 2003). Minorities are part of social capital and cannot be discounted from the overall social capital of the nation. Therefore, the academic progress of minorities in science, in this case physics, will add to the overall progress of minorities in the field of education and satisfy one of the conditions necessary for social change.

This study is also significant in its contribution towards others' professional development. Cooperative learning strategies could be fostered among the staff since the findings of the study were found to be significant. This kind of learning among teachers could, in turn, increase achievement among students (Anderson & Nashon, 2006; Coalition for Psychology in Schools and Education, 2006; Dana & Yendon-Silva, 2003; Dantonio, 2001; Donaldson, 2006; McWey, Henderson & Piercy, 2006; Mertens & Flowers, 2004; Rallis, Tedder, Lachman & Elmore, 2006; Torres-Guzman et al. 2006).

These findings may also be significant for instructors who teach in higher institutions of learning. Empirical research has found that university personnel are currently struggling to prepare teachers to be better prepared for the current system (Hammond, 2005). The findings from this study may benefit the preparation of those university instructors (Hoard, 2004; Bracey, 2002; Little, 2001).

Summary and Overview

All children should be included in a nation's educational plan for that nation to be qualified for success both nationally and globally (Hargreaves, 2003).There is evidence to suggest, however, that minorities are not included in many educational plans (Barth, 2001; Hargreaves, 2003; Sleeter, 2008). In response to this problem, cooperative learning, defined as children studying in small groups or, dyads, has been implemented as a strategy to improve the educational experience of minority students (Fredericksen, 1998; Fuller, 2001; Liu, 2005; Madrid, Canas & Ortega-Medina, 2007; Ochoa & Robinson, 2005; Novemsky, 2003; Tao, 2000). To further explore this relationship, the goal of this study is to assess the impact of cooperative learning on physics achievement by high school minority students.

Section 2 provides a literature review and consists of an analysis of literature referred to in Section 1. This analysis is a critical analysis of pertinent literature embodying the study. Literature citing the use of cooperative learning in general, the use of cooperative learning in science and physics, use of dyads, and the effect of professional development on achievement, have all been included.

Section 3 is the methodology section which consists of the participants, location, and the design of the study, hypotheses, and the main question. A description of the participants was included and a breakdown of the process of data collection. Reliability and validity were also accounted for in this section.

Section 4 contains the results of the experiments and a detailed description of how data was collected. A description of the data analysis and design is also found in this section. A summary of the data collected and the results of the data analysis are also provided in table form.

Section 5 dealt with the summary, recommendations and conclusion of the study. An interpretation section is also found on the findings of the study. A discussion on the literature review was also provided to show how the findings aligned with the literature reviewed.

SECTION 2: LITERATURE REVIEW

Introduction

Hargreaves (2003) established the need for all children to be successful in order for any nation to successfully compete with the rest of the world. This call included minority children and therefore implied that achievement is pivotal for the overall socio-economic prosperity of the nation ((National Survey of Student Performance, 2001; Bruschi & Anderson, 1994).

For over two hundred years, this problem of providing equal education for all children had been overlooked in the United States (Lambert et al., 2002). Dantley (2004), Stern (2004), and Sleeter (2008) have all recognized the need for minorities to improve in the area of achievement. Dantely (2004), Hoffer, Rasinski and Moore (1995), and Simmons (1993) have noted the poor performance by minorities in science while Nealy (2007) and Clark (1999) noted the under representation of minorities in the fields of science and technology.

Currently demographics in our schools have changed (Allison & Rehm, 2008; Goldenberg, 2008; Gandara, 2007). This change in demographics whereby minorities are becoming more dominant in the school system makes it more imperative for educators at all levels to work towards changing the status quo on achievement by minorities. It is with this changing situation on demographics that this study examines the relationship between cooperative learning and achievement in physics by high school minority physics students.

Literature Review Process

Literature review was gathered primarily from the Walden Library's data base. The ERIC section of the library's data base was the primary area targeted but I also obtained quite a few studies from other related areas such as Education, a full text collection. The Internet was also used to a lesser extent. Some information and studies were also taken from this source. Such terms as cooperative learning, collaborative learning, physics and cooperative learning, cooperative learning and science, high school physics and cooperative learning, achievement, achievement and professional development, achievement and physics, were used in the search for appropriate studies from all sources.

Theoretical Background

Dewey, Piaget, Bruner, and Vygotsky have laid the foundation for cooperative learning (Lambert et al., 2002). These authors attempted to show the significance of constructivism in a learning situation by using the theories previously developed by Dewey, Piaget, Bruner, and Vygotsky on how children construct meaning when learning is happening. Lambert et al. (2002), showed how learning can be enhanced among diverse students when they use a social setting to construct meaning. Lambert et al. also pointed out that "cooperative learning approaches provide a forum for the social construction of knowledge" (p. 22). When students learn in groups and when they are provided the opportunity to discuss view points with other students, this process of social interaction leads to authentic learning.

Children come to the classroom with a rich background of experience, which, when they interact with each other, produces new experiences and therefore results in new knowledge (Dewey, 1938). Dewey sees “education as a social process” (p. 58) and recognized the teacher as “a leader of group activities” (p. 59). Here it can be seen that Dewey has been a visionary of cooperative learning and constructivism.

Bruner (1987) recognized the child as a social being. Bruner (1987) sees making sense as a social process. Bruner, like Dewey, saw children making sense of their world through their experiences. Bruner recognized that children bring with them varying experiences to the classroom and it is in the context of these previous experiences that they interpret and negotiate meaning. Bruner also recognized the importance of words and expressions that relate to other words and expressions, thus constituting meaning. It is evident that group activities fulfill Bruner’s condition for constructing meaning. Bruner (1987) also emphasized the need for working in “dyads” in order to accommodate the co-construction of meaning.

From the constructivist perspective, new knowledge is constructed by linking previous knowledge and experiences to new constructs (Lambert et al., 2002). Teachers are called upon to integrate culture and tradition into their teaching to make schools more effective (Lambert et al., 2002) It is therefore assumed, that, when students learn in a cooperative setting, a social climate will be provided to afford them the opportunity to utilize their cultural and traditional experiences to arrive at new meaning and knowledge.

Physics learning consists of many technical and difficult terms (Novemsky, 2003). Lemke and Orr as cited by Novemsky equated the learning of physics with learning a foreign language. This difficulty of learning physics is likely compounded for minority students (Novemsky, 2003). From the constructivist perspective, this difficulty may be lessened by a cooperative learning setting.

Oser and Baeriswyl (2001) identified cooperative learning as one teaching model to increase learners' cognitive development. These authors viewed teaching and learning as different structures of a lesson. Teaching is viewed as a visible construct or structure (also known as a sight structure) and learning as an "invisible" (p. 1032) construct or structure (also known as mental operations). They emphasized the importance of "cueing the sight structures" (p. 1034) to the invisible structures (mental operations) to enhance learning. The theory then collapses into what is called the "choreographies of teaching" which sees teaching as a "step by step process" to align the visible with the invisible structures of learning (p. 1032). Cooperative learning is method of teaching that may accomplish this way of learning. This method of learning is viewed through the lens of social learning. Here the basis model sees social learning as a "dynamic relationship" to develop the ability to "solve problems" (p. 1056). This method of teaching and learning required training and the developing of appropriate skills by the students (Oser & Baeriswyl, 2001).

Learning physics involves much problem-solving. For example, a situation may be presented whereby a car starting out at rest accelerates with constant acceleration for five seconds. What velocity did it develop after the five seconds? The students will have to identify the concept and then choose the appropriate equation of motion that incorporates both the known and unknown quantities of the problem. Eventually, they will solve the problem for the unknown. The course is mathematically oriented as well as related to every day occurrences. Learning in a social context will lead to better understanding of the concepts as well as solving the problems easier.

Ethnographic studies have illustrated the importance of cooperative learning on minority achievement (Battisich, Solomon, Kim, Watson, & Schaps (1995); Zeuli & Floden, 1987). Battisich et al. (1995) established how disadvantaged students or low economic status students learn better when such students were provided with a sense of security and belonging. This sense of security and belonging could be provided when the school operates as a community (Battiscich et al.). A cooperative learning setting provided such a learning atmosphere and thereby helped minority students developed a sense of security and belonging.

Zeuli and Floden (1987) stressed that certain ethnographers see the need for classroom communication to fit specific background of the students while others stressed the need for the curricula to fit the cultural background. They believe that breakdowns in classroom communication between teacher and students were due to the fact that there was a mismatch between teacher and students' cultural background. They have pointed out that changing classroom background to fit for communication and cultural agreement does not mean changing the physical environment but applying the appropriate instructional intervention. The authors cautioned teachers about changing classroom situations to suit the learning patterns of students as making the classroom culturally congruent will not be an easy. They have pointed out the need for much consideration and thorough observation before implementing changes. The main purpose of introducing this study was to consolidate and strengthen the rationale for using cooperative learning in teaching physics to minority students as it could possibly have a positive effect on their learning.

General Support for Cooperative Learning

The following is some literature that supports the use of cooperative learning (Allison & Rehm, 2007; Attle & Baker, 2007). There were other studies which identified cooperative learning as an effective intervention for increasing achievement in general and specifically in science learning (Chang & Mao, 1999; Fuller, 2001; Madrid, Canas & Ortega-Medina, 2007; Munoz & Clavijo, 2000; Ochoa & Robinson, 2005; Saleh, Lazonder & De Jong, 2005).

The study done by Madrid, Canas and Ortega-Medina consisted of six boys and ten girls from a third grade elementary school. These students were subjected to three different conditions of learning: competitive team peer tutoring; cooperative team peer tutoring; standard teacher-led instruction. These students were studied for 15 weeks and then tested by giving them words to spell. The results showed that the cooperative team peer did better than the other two even though the competitive team peers also did well. The teacher led instruction did not show any significant improvement in performance.

Chang and Mao (1999) compared performance by Taiwan science students from junior high school earth science classes. They compared the performances of students exposed to inquiry learning versus traditional learning. The inquiry group also involved cooperative learning. Their results yielded significantly higher scores than the traditional group. The results also showed that those involved with cooperative learning performed much better than those who worked independently.

Fuller (2001) implemented a new teaching approach, Partners Advancing the Learning of Math and Science, called the PALMS approach in urban Massachusetts school district. Among the various elements being measured by this study, cooperative learning was one of the learning strategies involved. Participants were from diverse ethnic and economic backgrounds and demonstrated different learning styles. Participants were sampled from all levels, elementary, middle and high school. The major finding of this study showed significant positive outcomes in all areas affecting student growth. Since cooperative learning was one of the learning strategies used in this study it would be safe to conclude that cooperative learning had a positive impact on student achievement since the entire study had positive outcomes for all areas of student growth of which achievement was one of them.

Fredericksen (1998) showed how Hispanics showed significant improvement when they learned in a cooperative setting. This scenario covers a higher institution setting. Fredericksen cited David and Roger Johnson (1974) as reporting higher achievement by minorities when the use of a cooperative learning structure was made. The study also cited that “Mexican-American children display a more cooperative orientation than their Anglo-American peers” (p. 7). Even though more Hispanic students were graduating from El Paso University from a failure rate of 75% to a passing rate of 75-80 % than any other higher institution of learning, there were still many of these students finding it difficult to obtain jobs in the fields of science and technology. However, the author was optimistic that in time, “these cluster students” would find jobs in math, science, and engineering fields.

A study done by tertiary students showed how group grading not only moved the performance of students up but also reflected a deeper understanding of the learning material (Morgan. 2004). Participants from this study were taken from the school of education of Brownsville, Texas and were both Hispanic and non-Hispanic. All students were allowed to work in groups for about eight weeks. They were then allowed to take the exam in groups where they were allowed to discuss the question and solutions. The results from this cluster experience indicate a deeper understanding of the material by all students and greater achievement by all students. This study was only cited to show the effect of cooperative learning on achievement but was not used as a model by the researcher since the students who took the physics exam did so independently and not in groups.

Saleh et al., (2005) and Munoz and Clavijo (2000) both involved the study of minority students. Saleh et al. (2005) focused on 4^{th} grade elementary kids and Munoz and Clavijo primarily focused on African American 9^{th} and 10^{th} graders during a summer school. Both these studies illustrated significant achievement in the academic achievement of minority students; moreover, both studies used cooperative learning.

Cooperative Learning and Brain Based Research

Dwyer (2002) provided a new model for learning based on new research on the brain. Within this model, emotional safety was identified as an important condition for learning. Collaborative learning was seen as a quality of emotional safety, and an approach to ensure long term memory. This research provided empirical evidence linking cooperative learning to brain.

Cooperative Learning and Physics

Fikelstein (2005) and others (Lye, Fry & Hart, 2002; Park & Lee, 2004; Rennie & Parker, 1996) showed how students learning physics learned in context was critical. Fikelstein used students from Colorado University; Park and Lee used 28 High School students, 14 physics teachers, and 9 Korean university physics educators; Lye, Fry and Hart presented a case study of an Australian teacher; Rennie and Parker used 8 high school students from Western Australia. Again, these studies merely showed how students learned more effectively when the learning material was presented in a manner that was congruent to their experiences. These studies were used to show the need for using context in learning which the researcher used with the experimental class using groups of twos (Dyads). During the training session and during the experimental period students used their experiences to contextualize the learning material. Also to be noted from these studies were the fact that the students were learning in groups. And the third point about the studies was the fact that a physics lesson was used. This study substantiated the fact that physics learning consisted of terminology that could be quite strange and unfamiliar to its learners and hence the need for contextualizing such jargon.

Novemsky (2003) showed the effectiveness in learning in small groups when traditional ways of teaching were found to be unsuccessful. She believed that learning physics consisted of much technical and difficult terminology which can be easily learned in a small group setting which she called “second teaching”. She also connected her study to two of Vygotsky’s ideas: The use of language and visuals which had social and cultural implications, “zone of proximal development”, had to do with problem solving.

It was with these two ideas that Lisa Novemsky connected the use of small groups or cooperative learning. This study involved students from New Jersey inducted into a summer program of the Institute of Technology. The study found students showed significant preference and improved learning in small groups.

Tao (2000) was more relevant to the researcher's study of cooperative learning and physics achievement. It was relevant from the standpoints of the researcher that the study concerned high school physics students and the type of cooperative study, use of dyads, which were the two salient resemblances to the researcher's study. Tao (2000) used students which were well motivated and committed to their studies which were the likely case of the researcher's classes also. This study was organized into four different stages, pretest; feed back; posttest; and interview.

The pretest was given before students received any training in working in groups or cooperative learning. The posttest was given three and a half months after the feed back from the pretest. The analysis of the results from both pretests and posttests indicated significant improvement in the scores. Basically, the results from the study showed increased understanding when students were allowed to discuss and question each other's views. By engaging in such discussion, improved understanding evidenced by improved performance resulted.

This study was modeled partially by the researcher. The researcher used the same format (dyads) and had students discussed and questioned each other's views or answers or solutions during the learning time of each session. There was no comparison between pre and post tests but rather an analysis of score differences of the one group of students. There was a test given at the end of each practice session.

Rennie and Parker (1996) also did a study involving eight high school physics students, four boys and four girls. They set out to find the effect of learning physics in context, real life situations, versus abstract situations. Their findings indicated that the students learned better and more effectively when real life situations were used in the problems. The researcher made reference to this study to show the importance of involving the dyads in the experimental group to use their experiences and previous knowledge to help each other formulate physics concepts and derive solutions to problems.

Finally the following article, a top physicist turns to teaching (Bollag, 2007), was used to reinforce the need to implement cooperative learning in physics classes. This article talks of a renowned physicist, Carl, E. Weinman, who was the 2001 noble prize winner in physics. It was said that he gave up his research career for teaching undergraduate science at British Columbia University. His purpose of doing so was to devote his time to teaching because he wanted to move his current institution, University of British Columbia, and his former, the University of Colorado, away from lectures, toward "active and cooperative learning" (abstract). This article served to boost current science teachers, like the researcher, who wished to pursue the use of cooperative learning in finding more efficient and effective ways of increasing achievement by science students.

Ding and Harskamp (2006) used dyads to show how female dyads performed better than mixed dyads or just as good as male dyads when learning physics. They used fifty students from Shanghai, 26 females and 24 males, in this study. The students were taken from two physics classes from grade 11 with a mean age of 16. There were 12 mixed dyads (MG), seven female dyads (FF), and six male dyads (MM) in this study. Students were subjected to both a pretest and a posttest. Results showed that there were no significant differences in performance among the students in the pretest scores. However, in the posttest scores, students score significantly different. The female-female dyads performed better than the female-male dyads and performed equally well as the male-male dyads.

The main point in this study was that there was significant difference with female dyads. The study has good indications for improvement in performance among female physics learners if they learned in dyads as female dyads. This physics dyad suggested that females should be paired around the age group of 16 for cooperative studies.

A similar study on gender and dialogue in secondary school physics showed the effects of dialogue on understanding certain underlying concepts in physics by Tomlie and Howie (1993). The study concerned the explanation of the paths followed by falling objects. A pretest consisting of “prediction” and “explanatory” problems were administered to the students. Students were paired specifically for this study. A comparison of the results of two tests showed that the second scenario performed better than the first. The mean from the first was 1.13 and that of the second was 1.47. Participation in group work showed better results than independent. The major findings from this study were that group work yielded better results and that gender did matter. Female-female pairings apparently worked better than male-female and male-male pairings also did work well.

Tao (2004) in Hong Kong used 36 sophomore high school students and showed improvement in performance from pretest to posttest. He based his study on the premise of conflict, Piagetian, and co construction, Vygotskian, perspectives. His findings also showed that students were intensively engaged during the tests and learning was permanent. The main point in this study was that when students were confronted with conflicts as in problem solving in physics, they learned more effectively.

A significant relationship between communication and collaborative discovery learning was found by Saab, van Joolingen, and van Hout-Wolters (2005). They used 21 pairs of 10^{th} grade students from a school in the Netherlands ranging from 15 – 17 years of age. They worked in dyads on a physics problem involving particle collisions. The students communicated with each other during the discovery process via a chat box on a computer screen. For most of the time during the learning process much communication took place between the dyads. This study exemplified the effectiveness of collaboration between dyads of physics.

A study by Elfer-Wygand and Seitz (2001) used dyads in which students were paired according to their strengths and weaknesses in multiple intelligences by Gardner. This study showed how students when grouped in dyads with opposite strengths in multiple intelligences performed better than similar science students of ninth grade science classes who were grouped randomly. The study was done by pairing students according to mathematical disabilities and was later used in a follow up study in the ninth grade science classes. The initial study showed that when the students were paired by opposite strengths in mathematical skills and social skills, some students showed little improvement while others showed significant improvement. In the follow up study done by 9^{th} grade students from JHS 157 Q, students who were paired according to multiple intelligences, weaknesses and strengths, performed better than the ones paired randomly.

The main lesson to draw from this study was the use of dyads to pair students according to strengths and weaknesses which showed how the weaker students benefited and improved in science performance.

A study on the effects of cooperative learning program on the elaborations of students working in dyads in the Netherlands was done by Krol, Janssen, Veenman, and Linden (2004). 40 sixth grade students from seven elementary schools involved in school improvement program on cooperative learning from the east and south of the Netherlands were selected for the study. The students were split into two groups, a treatment group and a control group. Both groups worked on mathematics and a language task. Students were grouped according to their abilities; a low ability in math was grouped with a medium ability and a medium ability with a high ability, etc. The results showed that the school improvement program on cooperative learning positively affected the interactions of the student dyads. The use of cooperative learning in a dyadic setting does yield positive improvement in learning.

Learning elementary geometry in a collaborative dyadic setting was shown to be effective by Kumpulainen and Kaartinen (2003. These authors viewed “collaborative learning as a social meaning-making activity interdependent with cognition and social relations” (p. 336). Twenty 12 year old students from one Finnish elementary school participated in this study. These students were involved in a collaborative design task in which they used geometrical explanations to construct and evaluate meaning from their experiments. Data was collected from four, 25 forty min sessions in which only the second and the fourth involved dyads. Each session was videotaped and field notes taken. Another important feature of the dyads was that they were heterogeneous. During the analysis procedure only three of the dyads were selected for studying, a high, medium, and a low performing dyad. The results indicated that collaboration was effective for the high performing dyad but was challenging for the medium and low performing ones. There is however, that from this study it can be seen that "collaborative reasoning … can give students multifaceted opportunities to elaborate their mathematical understandings, geometrical sketching, and spatial thinking" (p. 367). This study illustrated the effectiveness of collaboration among dyads.

Achievement

The following studies describe specific cases of achievement and are used here to support the general idea of how schools and teachers implemented different strategies to improve achievement among students.

The following study showed when students worked in small groups to do problem based learning significantly impacted achievement (Cita, van Til, Cees, van der Vleuten & van Berkel, 1997). This study made use of the discourses that took place in small groups and showed that students who indulged in such learning behaviors performed better than those who would use other traditional forms of learning.

Thomas, Cox and Kojima (2000) showed how learning styles significantly impacted achievement among Japanese students. This study was done by 44 second-year Japanese college students pursuing an undergraduate degree in New Zealand. This study also factored in the cultural orientation with respect to learning habits of the Japanese and found that group was the preferred social style. This study is used here to show relevance to the current study and to achievement.

Yap (1997) in Washington showed how Bellevue public schools performed better at the district level than many other schools within the state of similar demographics. This study focused on students at the 4th, 8th, and 11th grade levels. In all three levels the District performed better than the state average for those three levels. This study did two sets of comparisons of data between the district and the state. Using four districts of similar demographics with Bellevue, Bellevue district achieved higher than the four schools. Another comparison was done with ten different schools and Bellevue again came out on top. The relevance of this study is with respect to the demographics of the Bellevue district. It had a higher percentage of minority students than that of the state. The data showed that even though there was a higher percentage of minorities present in this District, Bellevue still managed to out perform other districts in the state. This study served as an inspiration to the current researcher that minority children can perform equally well as or, even better than other children of the United States of America.

Achievement and Professional Development

The need for professional learning communities to be formed in order to enhance achievement in schools have been endorsed by Thompson and McKelvy (2007) and The Coalition for Psychology in Schools and Education (2006). Thompson and McKelvy recognized that learning communities are powerful resources that win the trust and appreciation of both adults and students. The article on the Coalition for Psychology in Schools and Education also supported the implementation of professional development in order to successfully pursue student achievement.

The researcher cited these two references to support the need for professional development so that the study on the effect of cooperative learning on minority students' achievement in physics can be fostered and encouraged.

Professional Development and School Reform

School reform necessitated the incorporation of professional growth in order to increase student achievement and teacher satisfaction (Wendy, 2001; Lick, 2000). Dana and Yendol-Silva (2003) have also recognized the need for learning communities and study groups to influence school reform. Dantonio (2001) stressed collegiality in improving instructional practices. Dantonio sees an integral relationship between good teaching and professional development and collegial relationships as an appropriate vehicle for achieving improvement in instructional practices. Donaldson (2006) gauged the success of teaching by gauging the success of the students. The relevance of professional development in student achievement and school reform cannot be more underscored.

Mertens and Flowers (2004) recognized professional development as the best way to increase teacher effectiveness in the class room and Torres-Guzman et al.(2006) showed the effectiveness of professional development in transforming a school from bottom up. Through professional development teachers were able to support each other, experiment with new strategies, and mentor new teachers.

Creating a community of practice reflected the social nature of learning (Rallis, Tedder, Lachman, and Elmore (2006). This article showed how a learning community developed appropriate thought processes to focus on instructional practice.

The researcher reflected on professional development at this juncture of the literature review to show how significant the study on the effect of cooperative learning on minority physics students' achievement can be in the context of professional development.

Professional Development and Cooperative Learning

McWey, Henderson and Piercy (2006) showed that cooperative learning is better than traditional teaching methods and also found that cooperative learning methods increased student achievement. In this study, the authors presented a case study of how one department of a college developed and implemented research teams. The study sought to find out (a) how cooperative research teams could be implemented across a department, (b) how specific cooperative learning teams operated on a day to day basis, (c) student and faculty perceptions of the use of research teams in graduate student education, and (d) what cooperative learning research team outcomes could be achieved. The study showed how graduate doctoral students who participated in it benefited a great deal. Many expressed satisfaction and have indicated that they had learned a lot.

The main lesson learned from this study was how teachers learned from each other when engaged in professional development by forming learning teams.

Physics and Metacognition

Anderson and Nashon (2006) did a study to show the effect of metacognition on the construction of knowledge. The study examined both the individual's and small collaborative groups' development of metacognition in the context of amusement park physics. There were two physics classes, an 11^{th} and a 12^{th} grade, with each group consisting of about 3-4 students. The classes were about 25 students each. Students were taken to the park and there participated in several activities that were physics related. After the visit, students were interviewed and also received questionnaires to complete. Students were also involved in classroom activities after their visit to the amusement park. After the post visit activities, students were again interviewed. The interviews and questionnaire results were analyzed in the context of a coyote rabbit metaphor, where, the coyote represented “predator knowledge” and the rabbit represented “canonical knowledge”.

The results of the analysis showed how one student possessed some of the characteristics of metacognition and the other was stronger in those deficient by the other. The interviews revealed that as a group, students were able to realize their strengths and weaknesses and together they emerged as a successful team, the rabbit did not die.

This study holds significance for the current study as students who participated in the current study would have also used their strengths to compensate for their weaknesses.

Teacher Training

The need for effective teacher preparation was stressed by Darling-Hammond (2005). Darling-Hammond compared the United States with several countries on how much was spent on education. Darling-Hammond recognized the need for teacher prep colleges to institute appropriate programs in their teacher prep courses such that teachers can be better prepared and be more relevant to the current trends of the society.

Summary

A rationale was established for studying the relationship between cooperative learning and achievement in physics by minority high school students. The theoretical underpinnings of the study were then established by making reference to constructivism, the basis model of learning and a couple of ethnographic studies involving minorities and cooperative learning. Finally, many studies connected with cooperative learning in general and involving minorities were identified. Specific studies involving the use of dyads and physics were also cited. Several studies involving achievement, school reform, and professional development were also identified as supporting the need to use learning communities to foster the use of cooperative learning and to highlight the significance of the study.

SECTION 3: RESEARCH METHOD

Introduction

The study was a quantitative investigation on the impact of cooperative learning on minority students' achievement in physics. The study stemmed from the poor performances of minority students in science (Dantley, 2004; Hoffer, Rasinski, & Moore, 1995; Simmons, 1993), as well as minority students' underrepresentation in the fields of science and technology (Nealy, 2007; Clarke, 1999). This poor performance that has led to the low socio-economic status of minorities (Gandara, 2008) necessitated educational reform through teaching strategies that can lead to increased achievement.

Research Design and Approach

A quantitative approach was employed to determine a relationship between cooperative learning dyads and student achievement in physics. A quantitative approach is used when a relationship is sought between two variables, an independent and a dependent variable (Creswell, 2003). In this study the independent variables were independent and cooperative learning, and the dependent variable was physics achievement. In order to show the impact of cooperative learning on physics achievement, a quantitative approach was used as the most appropriate paradigm for this study.

A repeated measures design was used because the sample was used twice, once in an independent learner setting, and subsequently in cooperative learning dyads. The use of the students in this manner required access to only one physics class. Because the intention in the study was to investigate the effect of cooperative learning teaching strategy on student achievement among minority high school physics students, the design was tailored towards the use of one group of participants as independent learners at one time and cooperative learners at a subsequent time.

Setting and Sample

The population of the school from which the participants were taken was approximately 2600. Of this number thirty two were selected to participate in the study because that number had been chosen from the beginning of the school year (2008-2009) by the guidance counselors and had since been learning physics as one class. The sample was therefore one of convenience.

The population of the school was of a diverse mixture consisting of 58 % Hispanics, 18 % Black Americans, 16 % Asians, and 8 % White Americans. The high school in question was also a Title I high school, meaning a significant percentage (61%) of the students received free lunch. The physics class under study consisted of 53% Hispanics, 9% Indo-Guyanese American, 25% Asians (3 Chinese and 5 Koreans), 6% Middle-Eastern (Afghan), 3.5% Black American (1) and 3.5% Indian American (1). Twenty (20) of the students were juniors and twelve (12) were seniors. Of those, 24 were boys and 8 were girls. Of the eight girls, there were two Asians and six Hispanics. Several of the students were English Language Learners (ELL) but the majority of them were fluent in English.

The sample size in the study was thirty-two. There was only one physics class in the school. Even though there was about some 2600 hundred students in the school, most of the students were selected for living environment and earth science. A very small portion was taken for chemistry and yet a much smaller portion for physics. Of course, physics then competed with two AP science classes, AP biology and AP environmental science. Many students also were reluctant to take Regents physics for fear it may be too difficult for them. Therefore the small number represented in this sample. However, the sample size met the minimum requirement for a quantitative study; thirty, (Gravetter & Wallnau, 2005) and this sample contained thirty-two. The researcher tried to ensure the sample size remained 32 having encouraged all the students to show up for the review session.

Participants

In order to participate in the study, students would have had to belong to the then current physics class. Also, students would have had to qualify as minorities (not being a Caucasian American) with mixed achieving abilities. If all of the students were excellent achievers in physics, there would not be any need for the study at this school. However, both students of excellence and the ones having difficulty in learning the subject participated in the study. Not many students from this group could have been characterized as excellent. The better students and the ones not so good were all expected to learn from this intervention since through dialogue and reflection; all students were expected to show improvement in learning (Kagan, 1994).

The research question in this study was: What is the impact of cooperative learning teaching strategy on physics achievement by high school minority students? This question suggested a need for improvement in physics achievement by minority students and an investigation into the possible effect of cooperative learning teaching strategy on achievement in this context. Therefore, a necessary criterion for participating in this study would have been poor achievement by some of the learners. Incidentally, many of the students did find the subject very challenging let alone there were other equally challenging subjects that were on their program at the same time.

Another significant criterion for the participants would have been that the sample be a reflection of the school's population. The school consisted of a diverse student body with a high percentage of Hispanics, a smaller percentage of African Americans and Asians, and a small percentage of Caucasians (8%). Since the percentage of Caucasian Americans was small, it should not be surprising that no Caucasian Americans were represented in the sample even though there were Caucasian Americans in previous physics classes. However, it could be safe to conclude that the sample was representative of the school's population since it did have a majority of Hispanics, a significant percentage of Asians, and a smaller percentage of Blacks and other minorities.

Intervention

The participants were allowed to participate in two different learning strategies. One of the strategies consisted of the use of the sample as independent learners that were allowed to solve certain physics problems taken from a past Regents Exam for one session. The other strategy consisted of the use of the group as cooperative learning dyads that also practiced solved problems from past Regents exams. This time the students worked in mixed ability dyads.

Each dyad was seated at a desk that accommodated two students. Dyads were not allowed to make contact with other dyads during the cooperative learning session. Although students were working in dyads at this point in time of the experiment, students were expected to solve the problems first on their own and then use the cooperative strategy to reflect on their solutions and problem solving processes. If for some reason a member of a dyad needed the help of the other member in the same dyad, the helping member must not share a solution or answer with the inquiring member. The helper must use a questioning strategy (See Appendix B) to help the other member in the dyad to arrive at the solution of the problem.

Each dyad was expected to use a four fold format strategy to help each member of a dyad reflect on each other's solution (See Appendix B). With the use of this four fold format strategy, members of each dyad was expected to correctly arrive at the solution of each problem and to have inquired into whether each other correctly arrived at the best possible solution. This strategy involved much dialogue between members of the dyads thereby promoting the use of social skills among the dyads to help members of the dyads to arrive at correct solutions of the problems. This process of dialogue also helped students to make meaning of each problem and construct solutions.

Instrumentation and Materials

There were two tests (See Appendix A) given that was taken from a previous state exam. Each test consisted of the same number of items that carried about the same score for each. The total scores for each test differed by one point. The topics and type of questions for each of the tests were not identical. For test one, questions for the test was based on momentum, friction force, electrostatic force and electric field. For test two, the topics were based on parallel circuits, electrical energy, and speed of sound in air and water. (See appendix A). None of the questions were repeated and therefore there was no possibility of any experience gained from taking the first test impacted upon the second test. The questions were completely different altogether and thereby preserving reliability and validity of the exams.

Each test was scored according to the state scores, meaning that each question was scored according to what the state stipulated at the end of each question. Each test was scored for the total stipulated and the percentage calculated. A percentage of 65 or higher would be deemed as an acceptable level of performance.

Materials used for both the practice problems and the tests were printed material on word processing. Students used the printed material and scrap paper. Students were also given an answer sheet on which they wrote their answers for the tests. Protractors and rulers as well as calculators were used during the practice problem solving for some questions as well as for the tests. Students also had access to a physics reference table which they used as needs be.

Reliability and validity of the tests would be internal and were based on the reliability and validity of the tests itself since they were taken directly out of two previously given state exams. Both tests were from a subsection of a previously given state exam. Each test was taken from the same subsection of the same year when the state exam was given.

Internal validity was ensured by using the same subsection of the state exam of the same year. One set of questions from the same subsection from the same year was used for the test given to the independent learners and another set of questions taken from the same subsection of the same year was given to the cooperative learning dyads. So, while the subsections were the same, the questions of the exams from which the tests were taken were not identical. Hence, there was no threat to the participants having grown in experience (Gravetter & Wallnau, 2005) having participated in one treatment that may have possibly influenced their experiences having participated in the other treatment.

Also, during the independent learning phase, a strict rule of no contact with each other was followed (Creswell, 2003). Students were instructed not to rely on any other during this phase of the experiment. The opposite occurred during the cooperative learning dyads phase. In this phase of the experiment, students talked with each other before arriving at the final answers during their practice session, prior to the exam. However, during the exam, students were not permitted to talk to each other. They did both tests independently.

External validity is further ensured when drawing conclusions from the results of the study. The researcher would be careful not to generalize the results to other groups of students (racial or social). Generalizations from this study would be restricted to this sample as well as to other students of similar ethnic, social, and economic status. In other words, students from similar minority communities stand to benefit from this study and would therefore, become valid to be included in the generalizations of this study (Creswell, 2003).

Statistical validity was confined to the scientific interpretations of the data obtained from the scientific analysis of the data collected. No statistical assumptions were made as all data were subjected to careful scientific analysis and interpretation (Creswell, 2003).

Each test was completed at the end of each practice session. Each test was designed to give students ample time to complete each question. Students were provided with a maximum of one half hour to complete each test.

Data Collection

Data were collected for duration of about two hours. Data were collected during a specially held review session of the class after regular school was closed out for the Regents weeks. Students worked on problem solving exercises as independent learners and as cooperative learning dyads for about two hours. Working under each different scenario alternated for two sessions. Therefore, students alternated between independent and cooperative learning dyads for solving problems and taking tests for topics on momentum, friction force, electrostatic force and electric field during the first session and on parallel circuits, electric energy, and speed of sound in air and water, during the second session.

The class of physics consisted of thirty-two students, 24 boys and 8 girls. These students had been learning high school physics since the school year began in September of 2008. Those students continued to learn high school physics known as Regents physics until the end of the school year, at which time they would have completed the Regents exams.

This group of students worked at one time as independent learners and at another time as cooperative learning dyads during the experimental phase of the study. During the independent phase of the experiment the class was randomly assigned to seats to work as independent learners. This random assignment to seats was accomplished by placing numbers in a bag corresponding to numbers placed on the desks. Students sat according to that arrangement for one session during which time they independently practiced physics problems. At the end of that session students took an exam that consisted of physics problems taken from a previously given state exam and very similar to those they practiced to solve on their own during the practice session (see Appendix A).

Following the second session, students sat as cooperative learning dyads. The class was divided into sixteen mixed dyads. Each dyad was based on ability to solve physics problems and not by gender or age. Dyads were strong-weak, middle-middle, or middle-weak. Based on previous performances of the students in the class, the students were classified as those with strong problem solving ability, middle ability, and weak ability. Once the strong ability students were determined, they were then asked to sit at specific seats and an equal number of weak ability students were asked to sit next to each of the stronger ones. The remaining students were grouped as middle-weak or middle-middle dyads. This arrangement was allowed for another practice session when students again tried to solve physics problems but this time in their respective dyads. Each dyad was given a specific format (Appendix B) to be used when solving each problem. Students would have had experience in this mode of problem solving before in class. Each dyad followed the format carefully and cooperatively practiced physics problems for that second session. At the end of that session, students were given a test that was administered independently also (See Appendix A).

Data Analysis

A *t* statistic was used to determine the relationship between the variables, the independent and dependent variables. The independent variables in this experiment were independent learning and cooperative learning and the dependent variable was physics achievement. A *t* statistic was used for related samples where in this case a single group was measured twice (Gravetter & Wallnau, 2005).

The data collected for independent and cooperative learning were in the form of test scores obtained from the review session. These scores were listed under the headings score1 and score2 that represented independent learning and cooperative learning respectively for each participant and then the difference of scores were obtained (See Table 1).

Participants Protection

All students who participated did so as a regular review class for the Regents exam. Signatures indicating their willingness to participate were not necessary for this study. Letters were not sent out to parents via email securing their permission to allow their child to participate in the study since the class was involved in regular review practice for the exam. Names never appeared anywhere in the study or the experiment. The name of neither the school nor its city was used or appeared anywhere in the study. All data – whether in hard copy or electronic form - will be safely stored for a period of five years.

Researcher's Role

The researcher was the primary data collector of the study. The researcher was actively engaged with the actual treatment but in no way participated in helping the students problem solved any of the problems. All problems whether they were solved independently or cooperatively were solved by the students. The researcher acted as a facilitator and was available to answer any questions students may have asked. When answering the questions, the researcher was careful not to give direct answers that could have influenced the student in arriving at the correct answer but all help was given merely to address any misconceptions.

SECTION 4: RESULTS

Research Question

This study examined the impact of cooperative learning dyads on the physics achievement scores of high school minority students. The null hypothesis expected no significant relationship between cooperative learning dyads and physics achievement by high school minority students. The alternative hypothesis was that there would be a significant relationship between cooperative learning dyads and physics achievement by high school minority physics students.

Data Collected

Data were collected from a special review session held prior to the Regents exam as specified in section 3 of the study. Two sets of tests scores taken from a review physics class consisting of junior and senior high school students were analyzed for a t test repeated measures design.

The scores were as follows:

Table 1

Scores Obtained From Independent and Cooperative Learning

Student	Score 1	Score2	Difference of Scores
1.	63	56	- 7
2.	50	22	-28
3.	38	44	6
4.	38	22	-16
5.	75	78	3
6.	25	67	42
7.	63	67	4
8.	50	56	6
9.	25	89	64
10.	13	44	31
11.	13	44	31
12.	100	89	-11
13.	50	44	- 6
14.	0	33	33
15.	50	44	- 6
16.	38	44	6
17.	75	78	3
18.	50	56	6
19.	0	0	0

20.	25	22	-3
21.	0	0	0
22.	50	22	-28
23.	38	56	18
24.	50	0	-50
25.	50	89	39
26.	13	78	65
27.	25	67	42
28.	38	89	51
29.	38	44	6
30.	50	78	28
31.	0	100	100
32.	38	67	29

Findings

A repeated measures design and analysis yielded a significant relationship between cooperative learning dyads and physics achievement by high school minority students [$t(31) = 2.640$, $p < .05$]. Thirty-two junior and senior high minority students were selected for this study and were paired according to ability based on previous performances in physics classes. The students were instructed to solve physics problems independently and then allowed to solve two questions from section C of a past Regents physics exam. Students were then allowed to solve another set of physics problems working in dyads. The students were then given two more questions to solve from the same section C of the same past Regents exam. The results yielded from the two tests given were then subjected to data analysis, a one sample *t* test analysis, and the results showed that students who worked in cooperative learning dyads performed better in the tests than when they worked independently.

The theoretical underpinnings of this study was constructivism and cooperative learning as espoused by such philosophical giants as Dewey, Piaget, Bruner, and Vygotsky, as cited in Lambert et al., (2002) and Oser and Baeriswyl (2001). These philosophers of education identify with making sense and meaning through prior experiences and previous knowledge. They also recognize cooperative learning as an excellent learning strategy for accomplishing this terrific task of constructivism.

The findings of this study were in line with the theoretical underpinnings of the study. It is clear that when students engage in discourse, utilization of social skills, cognitive structures are better stimulated for learning to take place. This learning construct seems to be evident in this study based on the positive outcomes.

Data Analysis

Because a repeated measures design was used in the study, the differences obtained from the two tests given were analyzed by a one sample *t* test pair analysis. The difference scores were calculated through SPSS software for one sample t test, and the following results were obtained:

Cooperative learning dyads impacted physics achievement with M = 14.31, SD = 30.67. The relationship was statistically significant, *t* (31) = 2.640, $p < .05$, $r^2 = .18$ According to the *t* distribution table for degree of freedom 31, the proportion for a two-tailed distribution is 2.042 (Gravetter & Wallnau, 2005). The results from the analysis show that the difference of the scores obtained fell beyond this critical region, 2.640. Therefore, the results are significant and showed a positive relationship between cooperative learning dyads and achievement in physics by high school minority students. The null hypothesis was therefore rejected.

The following tables revealed the statistical results from the analysis:

Table 2

One Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Score	32	14.3125	30.67250	5.42218

One Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Diff	
					Lower	Upper
Score	2.640	31	.013	14.31250	3.2539	25.3711

Conclusion

A significant relationship was found between cooperative learning dyads and physics achievement in a sample of 32 high school minority students. The students were grouped as independent learners for the first half of the experiment and then as cooperative learning dyads for the second half. Both tests were administered independently. The results obtained were directly from the learning arrangement, independent and cooperative learning dyads. The analysis of the data obtained from this experimental format resulted in a positive impact of cooperative learning dyads on physics achievement by high school minority students. It would be safe to conclude then, that, the relationship between cooperative learning dyads and physics achievement by high school minority students was significant.

SECTION 5: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Overview

This study was based on the fact that minority students were statistically lagging behind Caucasian Americans in science performance (Dantley, 2004; Gandara, 2008; Hoffer, Rasinski, & Moore, 1995; Simmons, 1993) and were underrepresented in the fields of science and technology (Clark, 1999; Nealy, 2007). Minority children are considered significant social capital to the nation (Hargreaves, 2003) and therefore cannot be discounted from the rest of the nation if the nation were to remain in a commanding competitive global position from both a political and economic standpoint (Gandara, 2008; Hargreaves, 2003). This study was therefore initiated to investigate a possible relationship between cooperative learning dyads and physics achievement by minority high school students because increased achievement among minority students can lead to better representation in the fields of science and technology (Clark, 1999; Nealy, 2007) and increased achievement may also impact the economy (Friedman, 2009; Gandara, 2008; Hargreaves, 2003).

Results obtained from the test results of high school physics students. Thirty-two students were selected to participate in this study and these participants were involved in working physics problems under two different conditions: once as independent learners and then as cooperative learning dyads. Students learning under each different condition were tested at the end of each different condition. The scores from the tests were then analyzed using a one sample *t* test and the results were examined.

There was one main review question which was: Is there a significant relationship between cooperative learning dyads and physics achievement by high school minority students? Based on this question a repeated measures design was used and a simple one sample *t* test analysis was done on the difference of scores. The results indicated that a significant relationship existed between cooperative learning dyads and physics achievement by high school minority students.

Interpretations

The findings from this study showed a significant relationship between cooperative learning dyads and physics achievement by minority high school students. While the overall findings are in clear support of the alternative hypothesis, it must be borne in mind that there were some dyads that did not agree with this finding. On careful examination of the difference in scores, some students showed a better performance in independent learning than in the cooperative learning dyads. Although most of the scores are consistent with these findings there are a few which were not. There is also a point which must be noted on the variance between the difference scores, $r^2 = .18$ which is in the middle range of effect (Gravetter & Wallnau, 2005). The effect must therefore be seen as just large enough to warrant the findings as significant.

A point to note is that this review was done just a couple of days before the Regents examination. It appeared as if some of the students were a bit unsettled and some what excited about other things other than their exam at this time. It is believed that these students did not give the exercise their best shot or put their best effort into it. As a result of that it is not surprising that some of the data collected seemed somewhat out of line with the findings. Had these students taken the review seriously as was expected there may have been more alignment with the data for the overall findings. Perhaps a better effect would have resulted also.

Due to the apparent tiredness and seemingly stressed out signals perceived from the students a decision was made to alter the data collection process from two days to one day as well as shortening the tests from a whole section ‘c’ of a past Regents paper to just two questions from such a paper for the independent learning test and two questions from said section and paper for the cooperative learning test.

Literature Review and Discussion

The body of literature for this study continues to endorse cooperative learning and the findings of this study provide further support for cooperative learning as an effective learning strategy. While some literature did support the use of cooperative learning as a strategy for developing social skills (Dwyer, 2002; Novemsky, 2003; Tao, 2000), and some as promoting achievement (Madrid, Canas & Ortega-Medina, 2007; Saleh, Lazonder & De Jong, 2005; Ochoa & Robinson, 2005; Fuller, 2001; Munoz & Clavijo, 2000; Chang & Mao, 1999), and others as promoting both (Fikelstein, 2005; Park & Lee, 2004; Lye, Fry & Hart, 2002; Rennie & Parker, 1996), this study reinforces the many others in supporting cooperative learning as an appropriate strategy for promoting achievement in science for minority children.

Particular attention must be given to the underachievement of minorities in science .Over the years minorities continue to occupy this lagging position in science performance compared to the rest of the nation (Dantley, 2004; Gandara, 2008; Hoffer and others, 1995; Simmons, 1993). Some minority groups have been closing the gap in some states (e.g., New York) but there still exists a wide difference in the performances between Caucasians and minorities in the areas of math and science (Gandara, 2008).

This study found a significant relationship between cooperative learning dyads and physics achievement by high school minority students. These findings provide promising evidence of an approach that might help to close this performance gap between Caucasians and minorities in science.

Nealy (2007) and Clark (1999) underscored the under representation of minorities in the field of science and technology. This under representation of minorities in the fields of science and technology also gave Goldenberg (2008) and others (Policy Alert, 2005) concern over the low socio-economic status occupied by minorities in the society. As is evident here there is some connection between fields of occupation and educational qualifications in science and technology which ultimately seems to have an impact on the socio-economic status of an individual (Friedman, 2009; Gandara, 2008). The findings in this study having found a significant relationship between cooperative learning dyads and physics achievement by high school minorities in some measure provides grounds for minorities to increase interest in higher learning science and thereby making their presence more pronounced in the fields of science and technology.

Hargreaves (2003) also made the point that it was pertinent for any nation to ensure the development of all of its peoples for it to survive and continue to occupy a global position from both an economic and political standpoint. The significance of this finding bears relevance to the overall progress of the nation as minorities continue to show improvement in science performance.

Professional Development

The need for professional learning communities to enhance achievement were underscored by Thompson and McKelvy (2007) and The Coalition for Psychology in Schools and Education (2006). Coupled with this, Dana and Yendon-Silva (2003) have also recognized the need for learning communities to influence school reform. The question then is: Is there a need for school reform?

School reform is an age old practice among educators and education forums. The call for school reforms never seems to have ceased. Yours truly has been involved in pedagogy for over twenty-five years and the topic of school reform has always been a current item on the educational agenda. It appears as if the subject of school reform is always a current topic of pedagogy and quite rightly so since education is a dynamic process. This concept of school reform is so current that the Mayor of New York City has been congratulated by the 44th President of the United States for the significant progress made with New York City Schools. The current (44th) President has also offered billions of dollars to schools which show significant achievement by their scholars.

There is no question as to the need for school reform among minority dominated high schools. Many inner city schools seem to be placing the emphasis on graduation rates rather than the quality of the graduates (Hall, 2007). So minority children are leaving schools impoverished of a good transcript and as such do not qualify for better courses that can qualify these students for higher paying jobs and jobs that are science and technology related (Gandara, 2008; Hall, 2007; Nealy, 2007). So they settle for mediocrity and useless offers. So many children are not only dropping out of high schools but are also failing to go far in their higher education learning. Can the nation afford this (Hargreaves, 2003)?

As a result there has been and still exists little emphasis on learning physics and chemistry. Physics seems to be the worse hit of the two subjects. The excuse has been that those subjects, physics and chemistry, are too challenging for minority children (primarily Black and Hispanic Americans) and so they offer those students less academically challenging subjects only to qualify for graduation.

There is much dire need for reform among minority dominated high schools. Such schools need to include higher science learning, such as physics and chemistry, and to encourage more minority children to pursue such studies in order to enhance both the individual and national status. With the findings of this study yielding positive outcomes in achievement by high school minority students, such schools should now be engaged in professional communities of learning to pursue the enhancement of teaching higher learning science to minority children.

Inclusion of higher learning science such as physics and chemistry in high school curriculum should be done with the intention of drafting a greater number of minority students into such courses because of both the individual and national interest. This will require, of course, greater expectations at all levels for minority children. There will also be needed appropriate teaching and learning strategies to accompany such efforts of school reform to include more minority children into learning higher science such as physics and chemistry. Dantonio (2001) relates good teaching with professional development and collegiality. Even though much research has been done on and does show cooperative learning to be a superior learning strategy, many educators still shy away and find little use of such an effective teaching and learning strategy and more so an appropriate one for minority students. Donaldson (2006) has also gauged successful teaching with the success of the students. Therefore, successful learning will follow effective learning strategies. Since this study has shown a significant relationship between cooperative learning dyads and physics achievement then it could be safe to foster this learning strategy among fellow science teachers which could possibly lead to improvement in achievement among minority science students. This good learning strategy must therefore be fostered through professional development and professional learning communities as the implementation of cooperative learning would depend on great collegiality (Dantonio, 2001).

This study focused on the use of cooperative learning dyads. Its practical use can therefore be seen by most minority dominated schools that seat students in twos as well as schools which are diverse. Students can be seated to learn in many different dyads; according to abilities, language, and any other dyads that could possible benefit the learners academically or socially.

There are a few points which must be noted at this point in the discussion. First, the number of students represented in the study was a little more than the bare minimum 32, 30 being the minimum. Perhaps, if there were two classes of students or three, the findings could be more valid. The assumption here is that greater the sample, greater the chances for a normal distribution (Gravetter & Wallnau, 2005).

Secondly, it must be noted how learning in dyads significantly effected the overall achievement of the students. In most of the cases there seems to be a clear case of increased achievement when students learn cooperatively in dyads as compared to when they did so independently (see data table , Table1). There were some cases in which this was not so. It may be construed from these results that those cases in which the dyads did not show a better performance than when they learned independently may have been due to the fact that those students who learned in cooperative dyads did not properly follow the instructions to learn cooperatively and may have still been trying to solve the problems independently while practicing to solve physics problems. Or, although they were practicing to solve similar problems they got on the test, they were not paying careful attention to the techniques they were using as dyads and when they did the test they were unable to retrieve necessary information they may have learned during the practice sessions. Or, as pointed out earlier, the questions in the independent learning test might have been easier for those students who did better in that test while the questions in the second test may have been more difficult for those said students. However, the findings from this study do promise well for physics students learning in dyads. It may be envisioned from here that if students are encouraged to learn together by using language, experience, and context, they should enhance their performance in science.

Another point which may be noted here and which may be considered as pertinent to this study is the fact that in the academic year (2007-2008) 58% of the students who took the Regents physics received a passing score of 65 and higher. This past academic year (2008-2009) 59% of the students passed with a score of 65 and higher with more of the students who passed got a grade higher than 65. This is significant to this study as it may be noted that these said students participated in the study and were practicing cooperative learning in dyads throughout the school year.

The fact was the students did not spend much time outside of their classroom studying for this subject. This information was learned through constant dialogue and inquiry into their attitudes, perspective, and academic behaviors. However, this was the first time in five years that students taking the physics regents exam performed that well without much external input in addition to that which they were getting from the class. Based on these circumstances it may be safe to conclude that learning in dyads cooperatively did impact achievement.

Implications for Social Change

How do the findings of this study hold for social change? The current situation is that minorities are underrepresented in the fields of science and technology (Nealy, 2007; Clark, 1999) due to the fact that they are underperforming in the area of science achievement (Dantley, 2004; Hoffer, Rasinski & Moore, 1995, Simmons, 1993). There may be instances of improved achievement throughout the nation but this improvement is not sufficient to bridge the gap that exists between Caucasian Americans and minority groups (Hoffer, Rasinski, & Moore, 1995; Simmons, 1993). There are still significant gaps existing between the two groups of people. However, the fact that this study has shown a significant relationship between cooperative learning dyads and physics achievement by minority high school students holds significance for social change among minority circles. Should this learning strategy be fostered among current minority dominated high school students who are currently finding science learning difficult and as a result are shying away or withdrawing from such higher science learning as physics and chemistry, this trend could strengthen the cause of science learning among minority learners and thereby provide grounds for improving the social status of minorities.

Merely showing a significant relationship between cooperative learning and physics achievement does not necessarily guarantee social change for minorities. However, there are certainly grounds for improvement in the areas of pursuing careers in science and technology as minorities may now be challenged to bravely pursue studies in these areas of higher science learning such as physics and chemistry knowing that there are definite learning strategies that can facilitate their learning for greater success. The aspirations and pursuits of minorities may now be lifted to a higher level as the possibilities of enhancing their social status may now exist at least in terms of being better represented in the fields of science and technology.

Recommendations

The fact that this study has shown a significant relationship between cooperative learning dyads and physics achievement by high school minority students, it can be safe to recommend further study of this teaching and learning strategy among minority dominated high schools. By doing further study with this learning strategy both in the current school and other minority dominated high schools will strengthen the need for this strategy to be used among minority science learners as well as to promote and foster the use of this learning strategy that could enhance science achievement by high school minority students.

This study involved the use of one particular cooperative learning structure, learning together in cooperative learning dyads. However, there are other cooperative learning structures (Jigsaw, snowballing, study buddies, etc.) which can possibly be used in physics classes to see how learning physics may be effected. By doing follow up studies involving a variety of these structures can strengthen the case for the use of cooperative learning in enhancing and fostering physics learning among minority high school students.

Increased achievement by high school minority students is not only a goal for many minority communities but the nation as a whole (Hargreaves, 2003). Since minority children form an integral part of the nation and increased achievement in science by minority students is pivotal to the overall progress of the nation and the world as a whole, it becomes critical for any nation, district, region or minority dominated school, to implement necessary learning strategies that will help achieve this goal. As cooperative learning dyads is proven to be effective from the findings of this study, it is therefore recommended both for further study and use in minority class rooms.

Principals, Assistant Principals for Science, Guidance Counselors, and Science Teachers are encouraged to foster the implementation of this learning strategy as it can enhance achievement among minority science students. These personnel within the school system are also advised to recommend students for higher science learning such as chemistry and physics regardless of their performance in math or some previous science course. All personnel dealing with students in selecting them for their science courses in fulfilling their high school requirements need to be reminded that minority children do not need to graduate from high school alone but also need to leave high school motivated for greater challenges in life like meeting the challenges of higher science and technology fields such as engineering and computer science. It is therefore significant to understand that by not affording minority students the opportunity of learning the higher sciences will undoubtedly deny and prevent minority children opportunities from advancing in the fields of science and technology.

It is also recommended that the results of this study be shared by other pedagogues as a professional development activity. Here it is believed that fellow teachers can ponder the significance of this learning strategy and thereby adopt it as part of their current curriculum or give it a try to see how it may affect achievement in science classes.

Conclusion

The primary lesson to be learned from this study for all educators is that learning anything is conditional on both learner and teacher setting up the appropriate environment conducive to learning and the teacher utilizing appropriate learning strategies that are commensurate with the learner's learning style. Teacher and administrative expectations are also pertinent to the learning achievement of the students as well. When students are perceived as not being able to learn certain disciplines, students are then denied certain academic opportunities as in the context of minorities and higher science disciplines. Poor expectations from educators lead to impoverished high school preparation and ultimately to under representation in the fields of science and technology. This eventually filters through the socio-economic strata and finally demoralizes minorities as this form of behavior pushes and suppresses minorities further down the lower end of the social and economic levels of the society. Ultimately this does not reflect well for the nation and the world at large in the context of changing demographics within the country placing minorities as the majority sooner than later.

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APPENDIX A.

Review Test 1

Base your answers to questions 1 and 2 on the information below.

A 1200-kilogram car moving at 12 meters per second collides with a 2300-kilogram car that is waiting at rest at a traffic light. After the collision, the cars lock together and slide. Eventually, the combined cars are brought to rest by a force of kinetic friction as the rubber tires slide across the dry, level, asphalt road surface.

1. Calculate the speed of the locked-together cars immediately after the collision. [Show all work, including the equation and substitution with units.] [2]

2. Calculate the magnitude of the frictional force that brings the locked-together cars to rest. [Show all work, including the equation and substitution with units.] [2]

Base your answers to questions 3 through 5 on the information below.

The centers of two small charged particles are separated by a distance of 1.2×10^{-4} meter. The charges on the particles are $+8.0 \times 10^{-19}$ coulomb and $+4.8 \times 10^{-19}$ coulomb, respectively.

3. Calculate the magnitude of the electrostatic force between these two particles. [Show all work, including the equation and substitution with units.] [2]

4. On the axes *in your answer booklet,* sketch a graph showing the relationship between the magnitude of the electrostatic force between the two charged particles and the distance between the centers of the particles. [1]

5. On the diagram *in your answer booklet,* draw *at least four* electric field lines in the region between the two positively charged particles. [1]

Review Test 2

Base your answers to questions 1 through 3 on the information below.

A stationary research ship uses sonar to send a 1.18×10^3-hertz sound wave down through the ocean water. The reflected sound wave from the flat ocean bottom 324 meters below the ship is detected 0.425 second after it was sent from the ship.

1. Calculate the speed of the sound wave in the ocean water. [Show all work, including the equation and substitution with units.] [2]

2. Calculate the wavelength of the sound wave in the ocean water. [Show all work, including the equation and substitution with units.] [2]

3. Determine the period of the sound wave in the ocean water. [1]

Base your answers to questions 4 through 6 on the information below.

A 5.0-ohm resistor, a 10.0-ohm resistor, and a 15.0-ohm resistor are connected in parallel with a battery. The current through the 5.0-ohm resistor is 2.4 amperes.

4. In the space *in your answer booklet,* using the circuit symbols found in the *Reference Tables for Physical Setting/Physics*, draw a diagram of this electric circuit. [1]

5. Calculate the amount of electrical energy expended in the 5.0-ohm resistor in 2.0 minutes. [Show all work, including the equation and substitution with units.] [2]

6. A 20.0-ohm resistor is added to the circuit in parallel with the other resistors. Describe the effect the addition of this resistor has on the amount of electrical energy expended in the 5.0-ohm resistor in 2.0 minutes. [1]

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APPENDIX B

Cooperative Dyads learning Format:

Each dyad will follow the following guide during their problem solving exercises:

Problem Solving Phase:

1. Identify the concept in the question.
2. Choose an appropriate equation that is representative of the variables in the problem (question).
3. Substitute for each variable in the equation.
4. Solve the equation for the unknown.

Reflection phase:

After solving each problem individually or each stage of the process, each member of the dyad will question each other on how and why they arrived at their answers. If there is disagreement, each member must explain their decision to each other. Students will also discuss their differences in the context of an answer sheet which will be provided.

CURRICULA VITAE

Educational Qualifications:

1. Currently Doctoral Candidate, Walden University (USA).
2. Masters in Learning Technology, 1998, Mercy College (USA).
3. BEd, University of Guyana, 1986, (Guyana, S.A.).
4. Professional Banking Certificate, 1995, (Manhattan, USA).
5. Teachers Certificate of Education, 1979, (Lilian Dewar College of Education, Guyana).

Professional Experiences:

1. Currently Physics and General Science Teacher, Flushing High School, Queens, New York (2004 – Present)
2. Physics and General Science Teacher, Enterprise, Business and technology, Brooklyn, New York (2000-2004).
3. Parochial School (K-8), General Science Teacher (1998 – 2000).
4. Parochial High School (9-12), Physics and General Science, (1998).
5. Bank of New York, Clerical, (1992-1998).
6. Bank of New York, Part and Full time (1998-2003).
7. North Georgetown Secondary School, Guyana, Head of Math and Science Dept. (1988-1990).
8. Bishops' High School, Math and Science Teacher, Guyana, (1979-1990).
9. Grove Elementary School, Math teacher, Guyana, (1975-1976).