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Under-represented Students' Engagement in Secondary Science Learning: a Non-equivalent Control Group Design

Joy J. Vann-Hamilton

ABSTRACT

UNDER-REPRESENTED STUDENTS' ENGAGEMENT IN SECONDARY
SCIENCE LEARNING: A NON-EQUIVALENT
CONTROL GROUP DESIGN

by

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Chair: Raymond Ostrander

ABSTRACT OF GRADUATE STUDENT RESEARCH

Dissertation

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Title: UNDER-REPRESENTED STUDENTS' ENGAGEMENT IN SECONDARY SCIENCE LEARNING: A NON-EQUIVALENT CONTROL GROUP DESIGN

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Problem

A significant segment of the U.S. population, under-represented students, is under-engaged or disengaged in secondary science education. International and national assessments and various research studies illuminate the problem and/or the disparity between students' aspirations in science and the means they have to achieve them. To improve engagement and address inequities among these students, more contemporary and/or inclusive pedagogy is recommended. More specifically, multicultural science education has been suggested as a potential strategy for increased equity so that all learners have access to and are readily engaged in quality science education. While multicultural science education emphasizes the integration of students' backgrounds and experiences with science learning , multimedia has been suggested as a way to integrate

the fundamentals of multicultural education into learning for increased engagement. In addition, individual characteristics such as race, sex, academic track and grades were considered. Therefore, this study examined the impact of multicultural science education, multimedia, and individual characteristics on under-represented students' engagement in secondary science.

Method

The Under-represented Students Engagement in Science Survey (USESS), an adaptation of the High School Survey of Student Engagement, was used with 76 high-school participants. The USESS was used to collect pretest and posttest data concerning their types and levels of student engagement. Levels of engagement were measured with *Strongly Agree* ranked as 5, down to *Strongly Disagree* ranked at 1. Participants provided this feedback prior to and after having interacted with either the multicultural or the non-multicultural version of the multimedia science curriculum. Descriptive statistics for the study's participants and the survey items, as well as Cronbach's alpha coefficient for internal consistency reliability with respect to the survey subscales, were conducted. The reliability results prompted exploratory factory analyses, which resulted in two of the three subscale factors, cognitive and behavioral, being retained. One-within one-between subjects ANOVAs, independent samples *t*-test, and multiple linear regressions were also used to examine the impact of a multicultural science education, multimedia, and individual characteristics on students' engagement in science learning.

Results

There were main effects found within subjects on posttest scores for the cognitive and behavioral subscales of student engagement. Both groups, using their respective versions of the multimedia science curriculum, reported increased engagement in science learning. There was also a statistical difference found for the experimental group at posttest on the measure of “online science was more interesting than school science.” All five items unique to the posttest related to the multimedia variable were found to be significant predictors of cognitive and/or behavioral engagement.

Conclusions

Engagement in science learning increased for both groups of participants; this finding is aligned with other significant research findings that more embracive and relevant pedagogies can potentially benefit all students. The significant difference found for the experimental group in relation to the multimedia usage was moderate and also may have reflected positive responses to other questions about the use of technology in science learning. As all five measures of multimedia usage were found to be significant predictors of student engagement in science learning, the indications were that: (a) technical difficulties did not impede engagement; (b) participants were better able to understand and visualize the physics concepts as they were presented in a variety of ways; (c) participants’ abilities to use computers supported engagement; (d) participants in both groups found the online science curriculum more interesting compared to school science learning; and (e) the ability to immediately see the results of their work increased engagement in science learning.

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A Dissertation

Presented in Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

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APPROVAL BY THE COMMITTEE:

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DEDICATION

In loving memory of my parents, **Lloyd O. Vann** and **Rosella F. (Jenkins) Vann.**
I am glad you knew that I was working on and would earn my doctorate. I thank you for the value you placed on education, although your opportunities were limited, and for instilling in me the drive, perseverance, and faith to accomplish anything that "I set my mind to."

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CHAPTER 1

INTRODUCTION

According to the European-led Organisation for Economic Co-operation and Development's (OECD) International Survey of Science Learning—Programme for International Student Assessment (PISA), 75% of the high-school survey participants indicated that science helped them understand the world around them, but only 57% indicated that science was personally relevant to them (OECD, 2007, p. 28). These statistics have far-reaching implications internationally, and particularly for the United States because a significant segment of the population, under-represented students, is under-engaged or disengaged in science learning. "If underrepresented minority groups, women, and persons with disabilities were adequately represented in science and engineering, there would be no U.S. talent gap" (Jackson, 2003, p. 3). Additionally, a number of research studies identified by Lee and Luykx (2006) illuminated the disparity between some students' aspirations in science and the means they have to achieve them. Therefore, this problem is a matter of national and individual interests, and increasing equity in science education and related disciplines for under-represented students *must be* (emphasis mine) a major priority in education.

Furthermore, results from the 2000 National Assessment of Educational Progress (NAEP) Science Assessment and the 2011 National Center for Education Statistics suggest not only under-represented individuals, but also secondary-level students, in general, are among the most under-engaged or disengaged. This outcome also intersects with other research indicating that student disengagement is particularly pronounced at the secondary level (Archhambault, Janosz, Morizot, & Pagani, 2009; Busteed, 2013; Center for Evaluation and Education Policy, 2005; Marks, 2000; Newmann, 1992; Sedlak, Wheeler, Pullin, & Cusick, 1986; Steinberg, 1996; Yazzie-Mintz, 2010).

To improve engagement and address the inequities among under-represented students in science learning, more inclusive and/or contemporary curricular and instructional approaches are recommended (Rodriguez, 2003). Atwater and Riley (1993), Ginovio, Huston, Frevert, and Siebel (2002), Hart and Lee (2003), and Lee (2003) suggested that the needed curricular and instructional reforms lie within multicultural science education to provide "equitable opportunities for *all* students to learn *quality* science" (Atwater, 1996, p. 468, original emphasis). More specifically, Lee asserted that "instructional congruence" (Lee, 2003, p. 474) mediates academic disciplines, such as science, with students' language and culture to make the academic content accessible and meaningful for all students (Lee, 2003). This also indicated that students' individual characteristics must be taken into consideration for engagement in science learning (Elmore & Huebner, 2010; Greene, Marti, & McClenney, 2008; Marks, 2000; Shernoff & Schmidt, 2008). Furthermore, in the work of Green, Brown, and Ramirez (2002) and Edwards (1999), multimedia was used as a tool to integrate principles and practices of multicultural education into learning to engage diverse students.

Statement of the Problem

A significant segment of the U.S. population, under-represented students, is still under-engaged or disengaged in science learning and related career fields. This reality means individual career choices are limited and national competitiveness is diminished. There are varied efforts to address this situation among educators and researchers and within federal and state governments. Among some educators and researchers, it has been suggested that more inclusive and contemporary curricular and instructional approaches be implemented to increase under-represented students' participation in science learning (Atwater & Riley, 1993; Ginovio et al., 2002; Hart & Lee, 2003; Lee, 2003, Rodriguez, 2003).

As for the federal government, current priorities include increased engagement and motivation in secondary education and increased usage of technology to deliver education and training. Concerning secondary student engagement, the U.S. Department of Education has introduced a new initiative called the High School Redesign that recognizes the pronounced disengagement among high-school students "that fails to put them on a path to college and career success" (ED.gov, 2013, p. 1). This is especially apparent in fields such as science, technology, engineering and mathematics (Archhambault et al., 2009; Busteed, 2013; Center for Evaluation and Education Policy, 2005; Chang, 2006; OCED, 2007; Yazzie-Mintz, 2010). In addition, not only federal but also state policies are facilitating the increased use of technology to enhance a student's learning experience. As a result, the number of students participating in online learning has seen considerable growth, estimated to be 1.8 million as of 2010 in comparison to 220,000 in 2003 (National Science Board, 2014).

While each of the aforementioned entities is focused on at least part of the problem, these efforts may be fragmented as priorities and approaches differ. However, in the current study, an effort was made to take into consideration all of the components including under-represented students' participation, inclusive and contemporary pedagogy, engagement, and technology associated with addressing the problem. As a result, this research explored how under-represented students' engagement in science learning in secondary education is impacted by multicultural science education, multimedia, and individual characteristics.

Purpose of the Study

This study examined the impact of multicultural science education, multimedia, and individual characteristics on under-represented students' engagement in science learning. The first, attributive independent variable was multicultural science education and was conceptualized with respect to instructional congruence and multicultural education. The second independent variable of the multimedia gauged the impact of the use of instructional technology on student engagement. The third independent variable concerned the influence of individual characteristics on students' engagement. The dependent variable included student engagement with respect to its cognitive, affective, and behavioral dimensions. However, exploratory factor analyses later conducted resulted in the retention of just two dimensions—cognitive and behavioral. Six principles were borrowed from the Seven Principles for Good Practice in Undergraduate Education (Chickering & Gamson, 1987). The impact of these variables was measured through the Underrepresented Students Engagement in Science Survey (USSES). Both a pretest and a posttest were used that participants completed while using either a multicultural or a non-multicultural multimedia version of the science learning activity. Participants were drawn from academic enrichment programs held on the campuses of five Midwestern universities that target minorities, first-generation college students, and/or low-income students. These participants are encouraged to complete their secondary education, enroll in, and graduate from institutions of postsecondary education.

Research Questions

RQ1: Are there differences in student engagement scores (cognitive, behavioral) by group (multicultural vs. non-multicultural) and by time (pretest vs. posttest)?

RQ2: Are there differences between experimental and control groups on multimedia use ("difficulty completing tasks," "ability to understand," " inadequate computer skills," "online science was more interesting," and "immediate results")?

RQ3: Is there a relationship between student engagement and multimedia ("difficulty completing tasks," "ability to understand," " inadequate computer skills," "online science was more interesting," and "immediate results") use?

RQ4: Is student engagement related to individual characteristics such as race/ethnicity, sex, science grades, and academic track?

Theoretical Framework

In this research, social constructivism was used as the unifying framework for the variables: multicultural science education, multimedia, individual characteristics, and student engagement, with its relevance to each variable illuminated.

Constructivism has affected the way researchers and educators conceptualize learning. With origins traced to the 6th century B.C., this learning theory is also associated with the work of Kant, Giambattista, Vico, Dewey, Piaget, and Vygotsky (Fetherston, 1999). As a result, different forms of constructivism exist. Social constructivism emphasizes the integral relationship among learning, language, culture, and social context. Learning or cognitive development is a function of social interaction to which language is integral. "Language . . . is the means of this social interaction" (Staver, 1998, p. 501). Social constructivism also recognizes individual membership in a particular culture. It promotes the idea that knowledge construction resides within cultures and is derived from human interactions within the environment (McMahon, 1997). In addition, knowledge is not only culturally, but socially constructed (Ernest, 1999; Gredler, 1997; Prawat & Floden, 1994). Social context includes the situation in which learning occurs as well as the sociocultural contexts individuals bring to the setting (Shernoff & Schmidt, 2008; Stagg, 2011).

Social context is also relevant to student engagement. Engagement contributes to students' cognitive and social development (Archambault et al., 2009; Finn, 1993; Newmann, 1992; Walker & Greene, 2009). It is through the socialization process that individuals learn to concentrate on tasks, whereas cognitively stimulating tasks and verbal interactions foster intellectual development (Marks, 2000). Csikszentmihalyi (1990) describes engagement as a "growth-producing activity through which the individual allocates attention in active response to the environment" (p. 52). Moreover, how students select to allocate their attention is based on "the interaction of several factors: their natural inclinations, the satisfaction they have derived from paying attention in other settings, and the value they attach to the activity based on its relevance to a future they anticipate" (Csikszentmihalyi, 1990, p. 78).

That researchers and practitioners are concerned about the engagement of students with social constructivism is noted by Gredler (1997) and Kim (2001). The following approaches are offered that are pertinent to this study to engage students in science learning with a social constructivist framework. One is "idea-based social constructivism" (Kim, 2001, p. 2), which encompasses a discipline such as science and, in particular, physics concepts in the current research. This approach also includes a focus on expanding students' perspectives, affecting the foundations of student thinking, and constructing knowledge (Clough & Driver, 1985; Stagg, 2011). These emphases also reflect the content integration of multicultural education and the instructional congruence of multicultural science education. In addition, student engagement, operationalized in terms of high standards and respect for diverse talents and ways of learning, is also relevant.

The second approach is a "transactional/situated cognition approach" (Kim, 2001, p. 3). This concerns the dynamic relationship between learners, the environment and their mutual influence (Bredo, 1994; Gredler, 1997). The social contexts in which learning occurs, as well as the sociocultural contexts that individuals bring to the setting, are a key consideration. Hence, the current research includes an examination of individual characteristics and their impact on student engagement (Greene et al., 2008; Haney & McArthur, 2001; Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008). The social relationships among those involved in a learning experience are also recognized and reflect faculty/student contact, prompt feedback, and time-on-task.

The third approach, known as "cognitive tools" (Kim, 2001, p. 2), can range from the use of metacognitive strategies, to hands-on projects, to the use of technology to assist learners in discerning sensory experiences and experiential knowledge (Dimitrov, McGee, & Howard, 2002; Green et al., 2002; Mistler-Jackson & Songer, 2000; Tsai, 2005). This reflects the intentional use of multimedia for the integration of the principles and practices of multicultural education and multicultural science education into the curriculum as well as to encourage active learning in this study.

Therefore, assuming that the social constructivist framework undergirding the variables in this study is appropriate, it logically follows that multicultural science education is associated with the idea-based approach. And, the consideration of individual characteristics that include transactional/situated cognition, and the use of multimedia or cognitive tools will engage under-represented students in science learning.

Significance of the Study

Given the need to broaden participation in science and related fields in the U.S., there must be representation from all of its citizenry. To increase participation among those who are under-represented, various researchers and educators have suggested that more contemporary and inclusive pedagogies are a fundamental response (Atwater, 1996, 2010; Banks, 2002; Edwards, 1999; Ginovio et al., 2002; Gay, 2002; Hart & Lee, 2003; Rosebery, Warren, & Conant, 1992). Moreover, research indicates that such instructional strategies may benefit all students (Rodriguez, 2003). At the same time, state and federal departments of education are focused on increased engagement among students in secondary education, with a particular emphasis on science, technology, engineering and mathematics (STEM) fields, and on the increased use of technology as beneficial to individual and national interests (ED.gov, 2013). This study was significant as it took into consideration all of the aforementioned emphases to address the problem in terms of multicultural science education as an inclusive and contemporary pedagogy, multimedia or technology usage, the individual learners involved, and has an emphasis on engagement in science learning. This unique combination of variables of multicultural science education, multimedia, and individual characteristics by which students' engagement in science learning at the secondary level was investigated is also distinguished from other student engagement, science engagement, and multicultural science education research as the current study investigated these constructs collectively. Therefore, it also offers an original contribution to the body of knowledge on multicultural science education, secondary science curricula, and student engagement research.

Definition of Terms

Individual Characteristics: In this study, race/ethnicity, sex, science grades and academic track represent individual characteristics.

Instructional Congruence: "The process of mediating academic disciplines, such as science, with students' language and culture to make the academic content accessible and meaningful for all students" (Lee, 2003, p. 474).

Multicultural Education: "An education for functioning effectively in an increasingly pluralistic and democratic society" (Banks, 2002, p. 97) that includes equitable opportunities for all students to learn.

Multicultural Science Education: An emphasis on continuity between students' cultural knowledge and practices and the learning environment to promote participation and engagement in science learning (Lee, 2003).

Multimedia: A tool to promote active learning and to infuse aspects of multicultural education into teaching and learning. And technically, it is "the seamless digital integration of text, graphics, animation, audio, still images and motion video in a way that provides individual users with [appropriate] levels of control and interaction" (Semple, 2000, p. 21).

Online Science: This refers to the multimedia science curricula designed for and used by the study's participants including the Seeing Yourself in Science® (SYIS) version for the experimental group and the non-multicultural version for the control group.

School Science: This refers to the completion of at least one secondary science course in which a computer or web-based science learning activity may or may not have been used and/or also includes students using the Internet/web to access science assignments or activities.

Social Constructivism: The idea that knowledge is socially and culturally influenced through the integral relationship among learning, language, culture, and social context.

Student Engagement: A multidimensional construct including affective, behavioral, and cognitive components reflected in "the attention, interest, investment, and effort students expend in the work of learning" (Marks, 2000, p. 15). It is also defined in terms of active learning, respect for diverse talents and learning, faculty/student contact, high expectations, time-on-task, and timely feedback, which are six of the Seven Principles for Good Practice in Undergraduate Education ("Six Principles").

Under-represented Students: Individuals under-represented in science and related careers, who may be female, and/or have a racial classification of African-, Native- or Mexican-American, Native Alaskan, and/or an ethnicity of Latino/Hispanic and/or who are low-income and/or first-generation in college attendance as a function of SES.

Delimitations

The study was limited to high-school students in Grades 9, 10, 11 and 12. In addition, the participants were enrolled in academic enrichment programs focused on increasing retention rates in secondary education and enrollment and graduation from institutions of postsecondary education. Furthermore, the study's focus was not on academic achievement in terms of grades but on participants' types and levels of engagement in science learning. Therefore, generalization of the outcomes to other subjects may be limited. The theme of the online science activity, the Kansas City Meteor Strike, was also a delimitation as it reflects a particular region of the country. In addition, the curriculum's science standards reflect those as prescribed by the Kansas and Missouri departments of education. Generalization of the research findings also may be limited to populations with similar racial, cultural, SES, linguistic, or gender characteristics.

Limitations

There is the possibility that participants may have interpreted some items on the USESS instrument differently than intended.

Summary

A significant segment of the U.S. population, described as under-represented students, is either under-engaged or disengaged, particularly in secondary science education. Student engagement has been identified as a viable antidote. Related research indicates that curricular interventions can improve low levels of student participation and achievement and high levels of disengagement (Fredericks, Blumenfeld, & Paris, 2004).

One such curricular intervention relevant to under-represented students and the barriers they face is multicultural science education, specifically directed at eliminating the discontinuity between students' cultural knowledge and practices and the mainstream science culture. Multimedia is another strategy providing multiple ways to engage diverse learners. Integral to these pedagogical strategies are individual characteristics, such as race/ethnicity and sex, which may have an effect on student engagement. These constructs of multicultural science education, multimedia, individual characteristics, and student engagement were examined in this study as participants interacted with one of two different versions of an online science curriculum.

CHAPTER 2

REVIEW OF THE LITERATURE

This literature review includes studies that conceptualize and complement the main variables in the current research as the impact of multicultural science education, multimedia, and individual characteristics on student engagement in science learning was examined.

The literature review is organized as follows: Student engagement is presented with respect to science learning and, more generally, as a multidimensional construct. Next, multicultural science education is conceptualized in terms of multicultural education and instructional congruence, which emphasizes the consideration of students' cultural knowledge and practices and individual characteristics, as an integral to science learning. Following this, the study's second independent variable of multimedia is highlighted by research that demonstrates the use of technology for the integration of the principles and practices of multicultural education and to broaden the form of knowledge available to students enhancing the "richness and reach" (Weigel, 2002, p. 41) of the learning experience. Similarly, studies related to the impact of individual characteristics on students' engagement in science learning are then presented. Lastly, a number of studies will address the validity and credibility of self-reporting as the majority of the studies included are based on students' self-reporting and because the current research utilized an adapted self-reporting instrument for data collection.

Student Engagement in Science Learning

The following studies regarding student engagement in science learning are undergirded by a social constructivist approach as previously identified in the theoretical framework.

Clough and Driver's research in 1985 reflects idea-based social constructivism. To better understand the conflict between students' experiential knowledge and scientifically accepted theory, students in middle and high school were interviewed about three tasks related to the conduction of heat. Based on these interviews, the researchers identified and compared common constructs that emerged from students' predictions and explanations about the conduction of heat for three objects made from different materials. Responses were grouped into mutually exclusive categories according to the type of explanation, including an uncodeable category for implausible responses. It was found that students' misconceptions about the conduction of heat began early in their education and persisted throughout their science learning. However, when participants were prompted to provide explanations beyond cliché facts, there was some increase in scientifically accepted explanations. For example, explanations for the heat conduction associated with the spoon/object experiment changed "from 27% in the 12-year-old group to 83% in the 16-year-old group" (Clough & Driver, 1985, p. 179). For the other two objects, explanations were incompatible and the percentage of uncodeable explanations was high. Therefore, helping students explore their "every day" understandings of scientific phenomena in more scientifically accepted ways is needed.

Stagg (2011), within an idea-based social constructivist perspective, explored inquiry-based teaching and sociocultural theory in a case study that focused on access to and quality of physics education. The study involved the design of the physics of circuitry curriculum for students in a diverse high school. As 15% of the students were English Language Learners (ELL), attention also was given to this dynamic. The teaching of the curriculum was shifted from instructor-centered to student-centered, which required the students to design and perform the labs in order to answer their questions about circuitry. Students worked in groups and then taught one another based on what they had discovered.

As is indicative of social constructivism, this approach was used to facilitate the students' generation of knowledge and greater ownership in learning. As students were more actively engaged in the scientific inquiry process and design, they not only were learning physics but also were participating in and demonstrating real-world skills. The outcomes of the study, based on surveys as well as interviews with the students, showed that some of the students struggled with the shift from the traditional, teacher-centered approach to the inquiry-based approach. This was especially evident for students who usually earned above average grades. Students whom previously had challenges with the traditional instructional approach seemed to be more engaged. For example, students came up with questions to research even before they had full command of "the formal language tools to describe all components of the circuitry" (Stagg, 2011, p. 34). In addition, while students reported deeper engagement in conceptual understanding, they also felt this came at the expense of their comfort with the mathematics and equations used. In terms of the impact on ELL students, 65% reported learning "very well" or "best" from the activities where they had a choice, while 57.5% of the non-ELL students indicated the same (Stagg, 2011, p. 36).

Chang's (2006) study reflected a transactional/situated social constructivist perspective, by examining the differences in 10th-graders' attitudes toward science learning in a computer-assisted learning environment when a teacher-centered or student-centered teaching model was used. The Constructivist Learning Environment Survey (Taylor, Fraser, & White, 1994) also was employed. The 347 students were part of eight groups and randomly assigned to either the teacher-centered or student-centered instructional delivery model. Participants were administered a pre-test which indicated whether they were less or more constructivist-oriented, "based on their average scores on the student-centeredness scale" (Chang, 2006, p. 799). Another survey, administered before and after the intervention, measured students' attitudes toward science with respect to their Earth Science classes. Findings showed that there were no significant effects on the outcome for either the teacher-centered or the student-centered instructional delivery model. However, an interaction effect was found between treatment and the instructional delivery model. The less constructivist-oriented students rated science learning more positively when they were part of the teacher-centered approach and the more constructivist-oriented students had more positive attitudes toward science learning in the student-centered learning situation.

The Constructivist Learning Environment Survey (Taylor et al., 1994) was also used by Haney and McArthur (2001) to examine the constructivist beliefs and teaching practices of pre-service science teachers. Again, a transactional/situated social constructivist approach was evident. During a science methods course, teachers focused on constructivist epistemology and then employed related teaching strategies during subsequent student-teaching experiences. Written documents, teaching observations, and interviews were analyzed using the constant comparison method. Teachers' constructivist beliefs and actions were coded with respect to five components of the Constructivist Learning Environment Survey or categorized as Other. Teachers' core constructivist beliefs, both stated and enacted, were constants in relation to components such as "student negotiation, scientific uncertainty and personal relevance" (Haney & McArthur, 2001, p. 786) and these were transferred to the student-teaching experience. However, "shared control" (Haney & McArthur, 2001, p. 786) or involving students in the content decision-making process remained a peripheral belief that was stated but not enacted among all the teachers.

Tsai (2005) utilized the "Constructivist Internet-based Learning Environment Survey (CILES-S)" to ascertain high-school students' perceptions of learning science in a constructivist Internet-based environment. The integration of the technology to extend the form of knowledge available in the learning experience exemplified the cognitive tools approach of social constructivism. The participants included 853 high-school students in 27 science classes. Science teachers administered the 40-question survey, which used a 5-point Likert scale ranging from *strongly agree* to *strongly disagree*. The questions were based on eight scales, some of which included the ease of navigating the science learning experience, the relevance of the science content, "multiple sources" and "cognitive apprenticeship" (Tsai, 2005, p. 205). Results showed that the mean scores for each of the CILES-S scales were above a value of 3, indicating a positive response to each feature of the CILES-S. The relevance scale had the highest score, suggesting that the Internet-based learning environment supported students in making meaningful connections between the science content and the real world. Scores were also high for ease of use, multiple sources and cognitive apprenticeship that indicated that students expected Internet-based science learning environments to be user-friendly, to offer a variety of resources for information, and to provide guidance and support for advanced learning (Tsai, 2005). In addition, there was a difference found for gender. Females scored higher on the relevance and cognitive apprenticeship scales than did males. This was seen as an indication that females may place higher emphasis on connecting the Internet-based learning to real-world situations and the option to obtain support from within the system or others as needed.

Student Engagement

As previously indicated, student engagement is a multi-dimensional variable with behavioral, affective, and cognitive dimensions, which reflect the dynamic and interrelated processes that occur within individuals. Student engagement has also been defined as the attention, interest, investment, and effort students expend in the work of learning (Marks, 2000).

Behavioral engagement is associated with effort and attention. Cognitive engagement concerns inner psychological qualities and is signified as an investment in learning. Affective engagement refers to students' emotional responses as evidenced by demonstrated interest in learning or academic tasks. It is also conceptualized as students' identification with the learning environment or sense of belonging (Finn, 1989). These dimensions of engagement and Finn's notion of engagement as a sense of belonging are resonant in the following two research studies.

The behavioral, cognitive, and affective dimensions of student engagement were examined with respect to their development and how these dimensions related to dropping out among high-school students. Questionnaires administered to more than 13,000 students over 3 consecutive years were used to gather information about several areas. These areas included behavior in the areas of conformity to school rules, participation in the classroom, and extracurricular activities; cognitive functioning including psychological involvement and the amount of effort put forth to learn; and the affective areas of feelings and attitudes toward school (Archambault et al., 2009). Behavioral engagement was assessed in terms of survey items that pertained to school attendance and discipline. Cognitive engagement items assessed the amount of effort students were willing to invest in the learning process, and affective engagement items "assessed student enjoyment and interest in school-related tasks" (Archambault et al., 2009, p. 410). This information was then compared to dropout status. Results indicated that students were highly engaged in high school; however, "one third reported changes, especially decreases in rules compliance, interest in school, and willingness to learn" (Archambault et al., 2009, p. 408). Moreover, students who were less engaged behaviorally from the beginning of high school were more likely to drop out.

Finn's (1989) social constructivist ideas that associated student engagement with a sense of belonging are also reflected in the study by Walker and Greene in 2009. This study examined high-school students' sense of belonging along with variables such as "self-efficacy, perceived instrumentality, and personal and classroom achievement and mastery goals" (Walker & Greene, 2009, p. 464). Students completed four questionnaires including one that pertained to demographic data, which were not analyzed; various items from three existing surveys were adapted to measure cognitive engagement, self-efficacy, perceived instrumentality, and personal and classroom achievement, which encompassed mastery and a sense of belonging. The questions were oriented to the classroom level, where the surveys were administered. Findings showed that “all of the means for the [above-mentioned] variables [for] . . . students’ motivation was relatively positive for [students’] English classes” (Walker & Greene, 2009, p. 467). A sense of belonging also was found to be significantly and positively related to self-efficacy, perceived instrumentality, and cognitive engagement and mastery goals. Cognitive engagement had a statistically significant relationship with a sense of belonging and perceived instrumentality. Mastery goals had a statistically significant relationship with self-efficacy and perceived instrumentality, and it was found to predict a sense of belonging. These outcomes suggested that a student’s sense of belonging in the learning environment positively affected student engagement, and that it may have an indirect influence on academic achievement with respect to cognitive engagement.

Evidence of the multi-dimensionality of student engagement is also reflected in the Seven Principles for Good Practice in Undergraduate Education (Chickering & Gamson, 1987). Six of these principles were used to conceptualize student engagement in the current study. Drawing on extensive research based on teachers’ and students’ academic and social interactions, the Seven Principles for Good Practice in Undergraduate Education (Seven Principles) were classified by a small task force of scholars.

The six principles included in the current research are paraphrased and include the following:

1. Encourage contact between students and faculty as essential for student motivation and involvement (Faculty/Student Contact).

2. Encourage active learning by interacting with content and applying what is learned (Active Learning).

3. Give prompt feedback such as hints, checking for understanding and assessment (Prompt Feedback).

4. Time-on-task involves effectively using time on academic tasks (Time-on-Task).

5. Communicate high expectations that students are capable of performing well (High Expectations).

6. Respect for diverse talents and ways of learning recognizes differences in learning styles with varied opportunities available for students to demonstrate their abilities (Respect for Diverse Talents and Ways of Learning).

There have been numerous adaptations and uses of the Seven Principles and these adaptations continue to evolve. The primary use of the principles has been in the National Survey of Student Engagement (NSSE) for postsecondary students. The Seven Principles also were reflected in the High School Survey of Student Engagement (Center for Evaluation and Education Policy, 2005), which was adapted for the current research.

The High School Survey of Student Engagement (HSSSE), a national longitudinal study, captured self-reported data about students' levels and areas of engagement or disengagement in academic work. HSSSE researchers aggregated the data and provided comprehensive, confidential reports to schools including comparison data with all other respondents. Selected findings from the 2005 survey reflected some of the areas of inquiry related to this research study. Results indicated that faculty/student interaction, collaboration among students on academic work outside of class, timely feedback from teachers on academic work, and cross-cultural interactions occurred, at most, 50% of the time or substantially less in these areas of engagement. Both the 2005 and 2009 reports showed that student engagement decreases from the first year to the senior year of high school, and males and under-represented students are less engaged and less likely to take college preparatory courses. The 2009 report also highlighted student boredom, a "temporary form of student disengagement," as an issue resulting from "uninteresting material and insufficient instructional interaction" (Yazzie-Mintz, 2010, p. 6).

Similar considerations of student engagement are found in *Engaging Schools: Fostering High School Students' Motivation to Learn*. The report by the National Research Council and the Institute of Medicine (2003) offered 15 recommendations based on numerous research studies to improve student engagement at the high-school level across different types of institutions. The recommendations, developed by a committee of educators and researchers, are synthesized in five classroom practices including: (a) the recognition of personal variables or individual characteristics in learning; (b) positive faculty/student interactions; (c) high standards and expectations; (d) curriculum and assessment that provided choices for students; and (e) pedagogy that was culturally relevant and authentic.

Multicultural Science Education

Multicultural science education is conceptualized in terms of multicultural education and instructional congruence. While a single definition for multicultural education continues to evolve, Banks (2002), considered the foremost authority on multicultural education, provided the definition most appropriate for the current research. Multicultural education is defined as "an education for functioning effectively in an increasingly pluralistic and democratic society," that includes equitable opportunities for all students to learn (p. 97). However, opponents describe multicultural education as an ethnic- and gender-specific movement or as an entitlement initiative (D'Souza, 1995; Matthews, 1994). They contended that multicultural education undermined the study of Western civilization in education at all levels. According to D'Souza in 1995, it is not the inclusion or study of other cultures sustaining the resistance but *how* the study of the West and other cultures is undertaken. The argument is paraphrased as follows: The major premise of multicultural education is the equality of all cultures. When traditional or Western education does not reflect this, multicultural education endeavors to emphasize "cultural parity by attacking the historical and contemporary hegemony of Western civilization" (D'Souza, 1995, p. 27).

This debate also extends to science education, where opponents reject the integration of multicultural education and even the constructivists approach (Stanley & Brickhouse, 2001). The objection stemmed from the Universalist epistemology which underlies Western or mainstream science. Matthews, in 1994, asserted that science is an "intellectual activity whose truth-finding goal is not, as principle, affected by national, class, racial or other differences" (Matthews, 1994, p. 182). However, it is these same factors that proponents of multicultural science education and others, such as the National Research Council and the Institutes of Medicine, argue as essential to consider in science education, particularly as it pertains to engaging under-represented student populations. Built upon the epistemology of social constructivists, proponents further contended that science disciplines and knowledge are socially and culturally influenced, if not constructed (Atwater, 1996, 2010; Mathison & Young, 1995; Stanley & Brickhouse, 2001).

Couched in the national science education reform movement for K-12, “Science for All” promoted the idea that students are capable of learning and should have the opportunity to learn quality science (Atwater & Brown, 1999). However, the realization of this idea is still lacking where under-represented students are concerned. Hence, Atwater (1996), from a multicultural science education perspective, expanded the idea to equitable opportunities for all students to learn quality science. This resulted from “multiculturalizing” science education (National Science Teachers Association, 2001, p. 3). Multiculturalizing science education involves a three-level model. Level One is “described as additive and tangible” (National Science Teachers Association, 2001, p. 2) as the perspectives and contributions of diverse scientists are inserted into the regular science curriculum. The second level relates these perspectives and contributions to the development of scientific concepts and discoveries. Level three encompasses social consciousness and advocating for multicultural science programs, equity, and even social activism so that science learning is made amenable to all students.

Multicultural science education also emphasizes continuity between students’ cultural knowledge and practices and the learning environment to promote participation and engagement in science learning (Lee, 2003). Continuity results from instructional congruence, which relates and “integrates academic content, such as science, with the students’ language and/or cultural experiences” (Lee, 2003, p. 474). It also encompasses dimensions of multicultural education such as “knowledge construction” and “equity pedagogy” (Banks, 1993, p. 26) wherein the cultural assumptions, perspectives, and biases within a discipline are challenged and knowledge generation and creation by students is encouraged. In addition, the integration of culturally diverse materials as intellectual resources with science content is included (Edwards, 1999; Fradd, Lee, Sutman, & Saxton, 2001; Ginovio et al., 2002; Lee & Fradd, 1996, 1998, 2001; Lynch, Kuipers, Pyke, & Szesze, 2005).

Research reflecting instructional congruence to promote student engagement in science learning is making an impact (Fradd et al., 2001; Ginovio et al., 2002; Lynch et al., 2005). For example, Fradd et al. (2001), in the study called Science for All (SFA), examined the relationship between literacy and science learning for English Speakers of Other Languages (ESOL). Curricular materials reflecting the students' languages and cultures were developed, and teachers and students were grouped related to the same ethnolinguistic traits and gender. Moreover, such grouping can be associated with cultural congruence. Marks (2000) asserts that this results in student engagement when there is support for learning in groups to which learners belong. In comparison with ESOL students who used the district-mandated curriculum, SFA students achieved significant gains in understanding in "both science concepts and inquiry" (Fradd et al., 2001, p. 494).

Whereas Science for All focused on instructionally congruent curricular materials, Hart and Lee conducted a study in 2003 that focused on the teachers who provided the curriculum and instruction for culturally and linguistically diverse students. This study examined teachers' initial beliefs and practices about teaching the English language and literacy in science as well as the impact of an intervention on these beliefs and practices.

Fifty-three elementary school teachers serving 1,500 students in a highly diverse school participated. Of the participants reporting, the majority of the teachers were female and Hispanic; 22 participants reported English as their first language, 18 reported Spanish, and six reported both English and Spanish. The teachers were given science curriculum materials and asked to teach two instructional units related to science at the third- and fourth-grade levels. Some indicated having taught science using school-adopted curriculum, and others indicated a fear of teaching science as they had never taught it before or they disliked the subject. The workshop interventions assisted the teachers in teaching the science curriculum, covering topics such as how to engage students in science inquiry and how to integrate the English language and literacy in science instruction. Focus group interviews and a questionnaire administered both at the initial workshop and again at the end of the school year were used to assess teachers' beliefs. Classroom observations were conducted to assess implementation and practice. The results from the first year of the longitudinal study showed that teachers expressed more detailed and logical conceptions of literacy in science instruction after the intervention and "provided more effective linguistic scaffolding in an effort to enhance students' understanding of science concepts" (Hart & Lee, 2003, p. 492).

A similar emphasis on instructional congruence was evident in the Rural Girls in Science project (Ginovio et al., 2002). In the first phase of the study, the gender-responsive, inquiry-based and hands-on curriculum, facilitated by female instructors, had a limited impact on the participants' commitment to science. Immediate post-evaluations indicated an increased interest in science and knowledge of science careers; however, follow-up after 1 and 2 years clearly indicated the inadequacy of the 2-week effort on participants for a long-term period. A second effort focused on school teams composed of some combination of math and science teachers, administrators, and selected girls. Longer-term research projects were developed and implemented during the school year with the continued emphasis on instructional congruence. Results were more substantive; the participants' interest in pursuing a science career compared with non-participants was substantially greater, 85% versus 24% (Ginovio et al., 2002, p. 314). At the end of participants' senior year, 85% planned to attend college and 47% intended to pursue a science or related major (Ginovio et al., 2002, p. 314).

Lynch et al. (2005) gave ancillary consideration to instructional congruence for improving educational outcomes of diverse students. A total of 1,500 eighth-graders from five ethnically, linguistically and socioeconomically diverse middle schools participated. Instead, a "highly rated" (Lynch et al., 2005, p. 7) reform-based curriculum was utilized, offering students different ways to engage with science content. The highly rated "Chemistry That Applies" (CTA) and alternative curriculum conditions were taught simultaneously. An ethnographic component also allowed researchers to "explore how the unit functioned in a diverse classroom setting" (Lynch et al., 2005, p. 8). Pretests and posttests for content, motivation, and engagement were administered. Findings indicated that the Chemistry That Applies curriculum increased mean scores in all three areas. Minority, lower socioeconomic status (SES), and ESOL students did better than their corresponding comparison groups, and in some cases, better than the majority comparison group of peers did. An interaction effect between curriculum condition and "current ESOL students" was an indicator that the content assessment "did not capture ESOL students' increased understanding, due to its literacy demands" (Lynch et al., 2005, p. 24). The ethnographic portion of this study also found "measurably distinctive but consistent patterns of verbal and nonverbal interactions" (Lynch et al., 2005, p. 31) among the four student participants reflective of their respective backgrounds and/or cultures as they interacted with the CTA curriculum.

Multimedia

Interactive multimedia as a tool for learning can broaden the form of knowledge available to students (Green et al., 2002). It also is used as a tool to integrate principles and practices of multicultural education into learning. For instance, Edwards's research (1999) employed multimedia to reverse stereotypical attitudes to increase minority student participation in science study and careers. Three versions of a multimedia software program were used in two biology classes. The "counterstereotypic version" (Edwards, 1999, p. 7) included images of African-American persons in high-status occupations with associated background information. Afrocentric images, positioned to be seen easily when students were answering questions, were selected to correspond to stereotype questions that pertained to African Americans. Students accessed the multimedia, biology review program in which the last pretest question activated a random assignment to one of the three versions of the program and posttest problems. Significant main effects were found for both software version and gender. The use of the counterstereotypic version was correlated with positive changes in stereotypes except in the classroom where culture was part of the discourse. In this classroom, there were no significant attitudinal changes, but biology knowledge increased. In the other classroom with no cultural discourse, those using the counterstereotypic version showed "less negative stereotypic attitudes compared with students using the same software without the counterstereotypic images" (Edwards, 1999, p. 1).

Mayer, Moreno, Boire, and Vagge (1999) used multimedia to examine working memory, also known as cognitive load, as a potential impediment to constructivist learning. The study included two experiments in which all participants received the same animation and narrations in a multimedia presentation. The presentation varied the cognitive load and hence the “opportunities for building the referential connections needed for constructivist learning” (Mayer et al., 1999, p. 639). Concurrent group participants received the narration and animation concurrently, and the two successive groups received either short segments of information with narration followed by animation or vice versa, or a large segment of information with full narration succeeded by full animation or vice versa. Tested on measures of retention, transfer, and matching, results among participants in both experiments were similar. There were no significant differences for the concurrent and short segments groups on the three measures. Statistically significant main effects were found for the large segments group whose scores were lower. In the second experiment, one difference was the matching test, where the concurrent group scored significantly higher than both of the other two groups.

Changes in students’ science proficiency were attributed to a multimedia learning environment in which alternative uses of technology were employed (Dimitrov et al., 2002). There were significant pretest to posttest gains for one of the three treatment groups which was attributed to the image analysis activities that enlivened the “richness” (Weigel, 2002, p. 41) of the content facilitated by the multimedia use. The alternative treatment group did not problem solve or complete image analysis activities, but instead studied the content of two science topics by accessing web sites and other resources. The other two treatment groups addressed either of the two topics and engaged in content-related and inquiry-based image analysis activities. To analyze the data, the Linear Logistic Model for Change was used to compare alternative uses of technology and to delineate trend and treatment effects. The three treatment groups (two regular and one alternative) were also compared to a control group. There were no statistically significant trend effects or changes in cognitive development, given the short pretest to posttest time period. Statistically significant treatment effects indicated gains in content understanding and problem solving for all three treatment groups. For the treatment group studying only one topic and with the greatest pretest to posttest gains in the aforementioned areas, the results indicated the importance of transferring knowledge and skills to novel contexts, and it was most effective to limit topics for more in-depth study.

Mistler-Jackson and Songer's (2000) case study addressed questions of students' views of learning science with technology and motivation. The study employed an Internet software program in the study of general weather topics, and the technology-facilitated interactions between students and science experts beyond the classroom. Such access to resources beyond the classroom reflected Weigel's notion of "reach" (Weigel, 2002, p. 41) to impact student engagement. Pretest and posttest assessments captured students' content understanding; a questionnaire was used to assess motivational levels from high to low, and interviews were conducted with a focus group of students. Among the focus group of students, those with low levels of motivation also showed the least accurate content understanding. Three students reported learning more through the technology-enhanced program, and the other three students indicated learning the same amount in a more traditional science course. Almost all students gave the instructional technology approach a high ranking in comparison with other science units. Regardless of motivational level, students cited the importance of "having more time to learn, the variety of resources available, active learning," and "the fun nature of the project" (Mistler-Jackson & Songer, 2000, p. 471). Reports by low and moderately motivated students of spending more time on the assignment because of the ability to use a computer were interpreted as increased motivation.

The Teaching, Learning and Technology (TLT) Group's Flashlight Project, especially designed for educational uses of technology, provided an item bank of questions that explicitly corresponded to the aforementioned Seven Principles. Moreover, five of the questions from the item bank were used in the current study to address the impact of multimedia use on student engagement. Based on the Seven Principles and through reviews of different versions by experts from five pilot institutions, the Flashlight Project bank of items has established content validity. In addition, face validity was established by pilot institutions with 40 different surveys composed of items from the item bank (Gilbert & Ehrmann, 1998). Focus groups for respondents, as well as for faculty and administrators involved in the results interpretation, were used to examine all of the teaching and learning items. Furthermore, a benchmark survey created from a standard template from the item bank and tested for validity and reliability has demonstrated, over a substantial time period, "a consistent Cronbach's alpha of .85 - .90" (Gilbert & Ehrmann, 1998, p. 3).

Individual Characteristics

Individual characteristics may also influence students' engagement in academic work. In a study of student engagement by Marks (2000), students' backgrounds, orientation toward school, authentic work, and social support were examined.

Participants in Grades 5, 8, and 10 took surveys in their math and science classes on factors such as attitude, behavior, and experiences in school, in general, and about personal and family background information. These factors were thought to affect engagement in academic work. Personal background encompassed items related to individual characteristics such as gender, race/ethnicity, and the "means of household items and household features and parental education" (p. 162) as a function of SES. Prior achievement included scores on standardized math and social studies tests. Orientation toward school considered student GPA's and behavioral issues in non-compliance with rules. Authentic work gauged how well and how often students were involved in academically meaningful experiences. Social support included high expectations for learning, parental support, and students' positive and negative experiences with other students as well as feeling safe in school and receiving fair treatment.

Results showed that overall engagement in academic work was a matter of individual student characteristics and experiences. However, engagement declined as grade level increased. One of the strongest personal influences on engagement was gender; females were more engaged across all three grade levels. However, the female gender effect was reduced by orientation toward school, authentic work, and social support. There were no racial or ethnic effects on engagement, and this was attributed to schools that had undertaken significant restructuring efforts to increase educational equity. Another personal influence on engagement was SES, which had significant effects at the high-school level, and prior achievement was significant only at the elementary level. Results for the other three independent variables also showed, for all three grade levels, academically successful students were more engaged than students who had behavioral issues (orientation toward school); authentic work engaged students and attenuated the SES effect for high-school students; and social support in learning and parental support positively impacted engagement in academic work.

Individual characteristics and their impact on student satisfaction were also examined in a longitudinal study conducted by Elmore and Huebner (2010). The effect of race, gender, and SES on student satisfaction was examined in more than 500 middle-school students in a 1-year period. Three measures were used to examine negative engagement behaviors: The “Inventory of Parent and Peer Attachment” (Elmore & Huebner, 2010, p. 528) to assess the influence of parents and peers on satisfaction; a self-report assessment with respect to “school, family, friends, self and living environment” (Elmore & Huebner, 2010, p. 529); and the “Behavioral Disaffection Scale” (Elmore & Huebner, 2010, p. 529). Findings between the first and second phases, referred to as Time 1 and Time 2 of the study, showed that gender, race, and SES were not significant with respect to school satisfaction. Results also showed that participants’ satisfaction with their school experience mattered more than relationships with parents and peers in determining school-related behavior. Thus, students’ school satisfaction predicted subsequent school engagement behavior for which significant differences were found. For example, at Time 1, “withdraw behavior” (Elmore & Huebner, 2010, p. 529), such as not wanting to be called on in class, was significantly different for students in Grade 8 than scores for students in Grades 6 and 7. Another significant difference was found for “Resistance/Aggression behavior” (Elmore & Huebner, 2010, p. 529), such as outbursts toward the teacher; scores for students in Grade 8, Time 1 differed from scores of students in Grades 6 and 7. The outcomes of this study have implications for the current research, as it may be that tendencies toward disengagement or disaffection behaviors are being carried over into the high-school years.

It was at the high-school level that Shernoff and Schmidt (2008) investigated similarities and differences in achievement, engagement, and quality of experience among Caucasian, African- and Asian-American and Latino students at 13 ethnically diverse schools. The “Experience Sampling Method” (Shernoff & Schmidt, 2008, p. 565) was used, which required students to wear wristwatches that emitted signals eight times daily for 7 days within a 15-hour period. Upon hearing the signal, students completed open-ended self-reporting forms with respect to their “location, activities and affective and cognitive experiences” (Shernoff & Schmidt, 2008, p. 565). Additional self-reporting surveys were used to capture information about academic achievement, engagement, and quality of experience. Moreover, on-task behavior at school, at home, and in public was also singled out for examination, as the researchers did not assume that being on-task equated to engagement. Findings showed significant differences with respect to racial/ethnic differences and GPA as African-Americans reported significantly lower grades than did Caucasians, and Caucasians reported lower grades than Asian students did. African-American students self-reported higher engagement in class than Caucasian students did. As for on-task behavior, “the positive effect of being on-task was over twice as high for [African-American] students compared to [Caucasian] students” (Shernoff & Schmidt, 2008, p. 572). African-American students also indicated that their level of engagement at home and school did not differ, whereas Caucasian students self-reported lower engagement at school than at home. These outcomes reflect an “engagement-achievement paradox” (Shernoff & Schmidt, 2008, p. 574); whereas higher levels of engagement translated into higher grades among Caucasian students, it was the opposite for African-American students. Hence, it seems that engagement may affect achievement differently with respect to race/ethnicity. Another possibility is that African-American students' self-reporting of their engagement was not accurate.

As the aforementioned studies involved the impact of individual characteristics on student engagement at middle- and high-school levels, the next two studies reflected their pervasiveness even at collegiate levels. Within the community college system, Greene et al. (2008) examined the differences in student engagement and academic outcomes among Hispanic and African-American students. Similar to the engagement-achievement paradox previously noted, Greene et al. found an "Effort-Outcome Gap (EOG)" (Greene et al., 2008, p. 529) among 3,000-plus participants. Students were administered the Community College Survey of Student Engagement (CCSSE) while in class and without prior notice. The survey reflected factors such as "class assignments, academic preparation and mental activities" (Greene et al., 2008, p. 521). In addition, the study examined course grades and pass/fails as well as all developmental and gatekeeper classes. In terms of engagement, results showed that African-American students reported higher levels of engagement than Caucasian students did, which was the reference group on all three factors. Hispanic students were similar to Caucasian students in terms of class assignments and academic preparation, but reported higher engagement in terms of mental activities, and Asian students reported higher levels of engagement than Caucasian students did on class assignments and mental activities. Academic outcome results indicated that African-American students had lower course grades than did Caucasian students and were less likely to pass courses, while Hispanic students had lower course grades but were just as likely as Caucasian students to pass a class. However, in the developmental and gatekeeper courses, although African-American students had lower grades than Caucasian students did, they were just as likely to pass these courses. Greene et al. intimated that the EOG may be a reflection of the extra effort that African-American students may need to put forth in order to overcome academic and institutional barriers to educational progress and success.

Kuh et al. (2008) conducted a study of the relationship between student engagement, academic achievement, and persistence among college students at 18 colleges and universities that granted bachelor's degrees. While a number of variables were considered, the impact of engagement "in educationally purposeful activities" (Kuh et al., 2008, p. 555) during the first year of college on first-year GPA and persistence to the second year were studied. Any differences with respect to race and ethnicity were also identified. In the second stage of the analysis, the influence of study time and engagement on academic-year GPA and persistence differed by student background characteristics. The impact of engagement on first-year GPA scores was found to differ by students' race and ethnicity, but only for Caucasian and Hispanic students. However, African-American students benefited more than Caucasian students did from increased engagement, which translated into comparable and even higher persistence levels.

Self-Reporting

The majority of the studies highlighted in this literature review rely on student self-reporting, which raises questions about the validity and reliability of self-reporting data. As for HSSSE and the adapted USESS version utilized in the current study, the instruments share the same psychometric properties and quality of the NSSE, which was the original instrument designed to satisfy five general conditions for validity including:

> (1) When the information requested is known to the respondents
> (2) The questions are phrased clearly and unambiguously
> (3) The questions refer to recent activities
> (4) The respondents think the questions merit serious and thoughtful response
> (5) Answering the questions does not threaten, embarrass, or violate the privacy of the respondent or encourage the respondent to respond in socially desirable ways. (NSSE, 2002, p. 3)

Beginning with the first administration of the NSSE, at least five psychometric analyses of its items and scales with over 300,000 students have been conducted to establish validity and reliability. In addition, focus groups with first-year and senior-level students were conducted at public and private colleges to ascertain respondents' understanding and interpretation of various survey items. Results showed "high face and content validity[,] responses to survey items [were] approximately normally distributed and the patterns of responses to different clusters of items discriminate[d] among students both within and across major fields and institutions" (Kuh, 2002, p. 5). Among the focus groups, the vast majority of items were "valid and reliable and [had] acceptable kurtosis and skewness indicators" (Kuh, 2002, p. 19). However, there is still the possibility that respondents will interpret some items differently than intended.

More recently, the validity of NSSE has been challenged by researchers such as Porter, Rumann, and Pontius (2011). The "four-stage model of survey response" (Porter et al., 2011, p. 88) was used to analyze NSSE's academic challenge questions in regard to "comprehension, recall, judgment, and response" (Porter et al., 2011, p. 88). Comprehension was said to be an issue based on some of the dated and vague language of the questions. Recall was noted for information students were expected to retrieve accurately given the period between the actual events and the survey administration. The researchers also noted the academic challenge questions were mundane to begin with, and therefore the reliability of recall was already diminished. Judgment was at issue, as the amount of information and its accuracy over time were suspect of reflecting the number of memories recalled versus actual event frequency. Response was identified as students were required to match their answers to ambiguously worded scales; for example, “often,” “very often.”

The research design examined the validity of the academic challenge questions on NSSE 2011, using students’ transcripts and course syllabi, which were coded and then compared to students’ self-reporting of the number of books assigned in classes taken. The adapted survey included two major changes: a shortened timeframe from the current semester instead of up to 1 year for recall for the questions to which students responded, and the response scale distribution was shortened from “none” to “more than eight” in reference to recalling the number of books assigned in classes. To compare the actual and self-reported number of books assigned, the actual number of books assigned was condensed to match the six response categories on the survey. Findings showed a “correlation of only .38 between the actual and self-reported number of books and only 21% of the 925 students provided a correct answer” (Porter et al., 2011, p. 96).

Laing, Sayer, and Noble (1988) found a high level of accuracy of self-reported data among college-bound high-school students. Twenty-nine items from the Student Profile Section of the American College Testing Assessment (ACT) were selected to examine the face value of students’ reports of their activities and accomplishments as provided on their ACT Assessment records. Student responses on the five items pertinent to background characteristics, the 9 items pertinent to extracurricular activities, and the 15 items relevant to special accomplishments were compared with responses provided by their respective school staff. Three categories for responses were established: congruent responses where both students and the school responded "yes" or "no"; incongruent responses where students and the school responded opposite; and incomplete responses where students and/or the school responded "don't know" or left an item blank. Among the 477 participants, "the median percentage of student-school incongruent responses was about 10%," based on 24 activities and accomplishments items, "with about 6% claiming credit for an activity or accomplishment that the school said they were not entitled to" (Laing et al., 1988, p. 368). Background characteristics with the highest level of incongruence were high-school rank and school programs such as college preparatory and vocational track.

A similar study involving college-bound students' self-reporting of High School GPA (HSGPA) indicated on the SAT compared to their school-reported HSGPA was undertaken by Shaw and Mattern (2009). The students were part of "the national SAT admission validity study sample . . . whereby colleges and universities provided first-year student performance data for the entering class of fall 2006" (Shaw & Mattern, 2009, p. 2). Self-reporting of their HSGPA versus school reports of HSGPA was compared across all students and with respect to gender, race/ethnicity, and parent education and income. The HSGPA was based on a scale from 0.00 to 4.00, in keeping with what the majority of colleges and universities used, and to be consistent with national research on the HSGPA from the 2005 U.S. Department of Education High School Transcript Study (Shaw & Mattern, 2009). Results among all students for gender and race are noted since these factors are pertinent to the current research. Among all students, about 52% of students self-reporting matched their school-reported HSGPA. “Of the remaining 48 percent, 29 percent [of students] underreported and 19 percent over-reported their HSGPA” (Shaw & Mattern, 2009, p. 4). Females more accurately reported their HSGPA compared to males, but females and males over-reported and under-reported their HSGPA at relatively the same rate. As for race/ethnicity, “African-American students had the lowest exact match rate at 42 percent, while students of Asian descent had the highest exact match rate at 55 percent” (Shaw & Mattern, 2009, p. 4).

The accuracy of self-reported grades is extended to the college level in a study conducted by Cole, Rocconi, and Gonyea (2012). These researchers drew data from over 12,000 freshman and senior students from the NSSE. In particular, they examined the survey item that asked respondents, “What have most of your grades been up to now at this institution? The response categories were grouped to reflect overall grades of A, B, or C for both the self-reported and the institution reported GPA” (Cole et al., 2012, p. 5). Results indicated that students who had a cumulative GPA in the range of A/A- provided the most accurate self-reporting. This was relatively the same for students in the range of B+/B; however, students in the range of C+/C or lower “were the least accurate with only 42% reporting accurately” (Cole et al., 2012, p. 6). Moreover, when the researcher examined the accuracy of self-reported grades with respect to achievement levels, it was found that high-achieving students tended to over-report low grades just as low-achieving students did. According to these researchers, their hypothesis is supported that students tend to over-report low grades rather than experience a “cognitive distortion” (Cole et al., 2012, p. 8) due to an error in recall. As for differences between self-reported and institution-reported grades, overall the two measures were very similar.

Summary

This literature review included research that addressed the study's main variables as well as those that conceptualize and complement these variables to examine the impact of multicultural science education, multimedia, and individual characteristics on student engagement in science learning.

Student engagement was presented concerning science learning and as a multidimensional construct. Student engagement in science learning was the theoretical framework of social constructivism and its idea-based, transactional/situated cognition, and cognitive tools approaches. For example, Clough and Driver's (1985) research, supported by idea-based constructivism, examined students' experiential understandings about heat conduction and found that misperceptions began early and persisted in science learning. Stagg's (2011) research emphasized improving high-school students' understanding of physics concepts when a student-centered approach was used. While conceptual understanding increased, some students were challenged by the student-centered approach. Additional studies on student engagement in science learning reflected a transactional/situated cognition approach. In Chang's (2006) study, students who were less constructivist-oriented rated science learning more positively with a teacher-centered instructional delivery model; while, more constructivist-oriented students rated science learning more positively with student-centered instruction. Haney and McArthur's (2001) focus on pre-service science teachers' constructivist beliefs and practices highlighted the difficulties of the teachers in sharing control with students in the content decision-making process. Teachers' constructivist beliefs did not correspond to their actions in the classroom. A final study demonstrated the cognitive tools approach as Tsai (2005) conducted research that found high-school students' perceptions of learning science in a constructivist Internet-based environment to be favorable. In addition, a difference related to gender also showed that females placed more emphasis on connecting the learning to the real world, which has implications for addressing the gender gap in science learning.

The multi-dimensionality of student engagement was demonstrated by a variety of studies with respect to its affective, cognitive, and behavioral dimensions. In two studies (Archambault et al., 2009; Walker & Greene, 2009), student engagement, among high-school students, was equated with a sense of belonging. In both studies, a sense of belonging increased student engagement. The three dimensions were also part of larger scale assessments of student engagement such as the NSSE, HSSSE and NRC (National Research Council and the Institute of Medicine) that identify and/or capture similar factors that promote or detract from engagement in learning. Student engagement was also conceptualized in the current study through six of the Seven Principles for Good Practice in Undergraduate Education (Chickering & Gamson, 1987). The six principles are also reflected in the items on the HSSSE as well as complementary to the five effective classroom practices for student engagement recommended by the NRC. Moreover, each of the six principles is related to one of the three dimensions of student engagement; these dimensions are also reflected in its definition of the behaviors of effort and attention, the affective mode of interest, and the cognitive investment of students expended in the work of learning (Marks, 2000).

Proponents and opponents of the integration of multicultural education and Western mainstream science education point to almost identical variables associated with national, class, racial and other differences as essential or nonessential influences respectively, on students' engagement in science learning. The Universalist epistemology of mainstream science education maintains that the influence of individual characteristics on the construction of knowledge is negligible and is usurped by the permanent reality of the natural world (Matthews, 1994). Social constructivism, which provides an epistemological rationale for the pedagogical orientation of multicultural science education, deems the sociocultural context of the learners, the learning environment, and their mutual influence as the lens through which knowledge is constructed (Atwater, 1996; Matthison & Young, 1995; Stanley & Brickhouse, 2001).

The multicultural science education studies emphasized instructional congruence or continuity between students' cultural knowledge and practices and their learning environment. The majority of the studies showed gains among participants in academic performance; changes in teachers' attitudes and sometimes practices; and increased student interest and/or participation in science (Atwater & Brown, 1999; Fradd et al., 2001; Ginovio et al., 2002; Hart & Lee, 2003). In the last study (Lynch et al., 2005), where instructional congruence was ancillary to a reform-based science curriculum, under-represented students made significant improvements in learning. However, the study's ethnographic component found that the literacy demands of the ESOL students, based on their respective backgrounds and/or cultures, still were not adequately addressed.

Multimedia accommodated differences in students' backgrounds, skill levels, learning styles, and/or was used to broaden the form of knowledge available to students. For example, Edwards's 1999 study demonstrated the use of multimedia as a tool for the integration of the principles and practices of multicultural education to counter stereotypical attitudes about minorities in science study and careers. Among the students using the counter-stereotypic software version in their biology class, results included fewer stereotypical attitudes. For other students where cultural discourse occurred in class, biology knowledge increased. Mayer et al. (1999) used multimedia to better understand the relationship between cognitive load and constructivist learning. In the two experiments where animation and narration were used and the cognitive load was varied, lower scores resulted among participants who received larger segments of the information. In the second experiment, participants with higher scores were those who had received the animation and narration information concurrently. Multimedia was also used in another study regarding changes in students' science proficiency involving simulations and image analysis activities to aid in conceptual understanding (Dimitrov et al., 2002). Participants with the best outcomes were able to transfer knowledge and skills to novel contexts. Mistler-Jackson and Songer (2000) used an Internet software program and technology to connect students and science experts beyond the classroom, which was indicative of Weigel's (2002) ideas of richness and outreach. Participants ranked the technology-integrated science curriculum higher in comparison to a more traditional curriculum. The impact of the use of technology on students' motivation was also assessed, with the least motivated students reporting increased time-on-task and motivation because of the technology use.

When studies reflecting individual characteristics on student engagement were examined, Marks's (2000) research showed that some individual characteristics and experiences within the classroom significantly affected student engagement. Females were more engaged, and personal variables such as SES, positive orientation toward school, authentic work, and social support were particularly significant for the high-school students. Race/ethnicity had no significant effect on engagement and this was attributed to reforms for more equity in education that the participating schools had previously undertaken. In Elmore and Huebner's 2010 research, neither race, gender, nor SES was found to be significantly different when school satisfaction and student engagement were examined. However, school satisfaction predicted student engagement and students also demonstrated fewer negative behaviors. Three additional studies suggested that the individual characteristic of race had an impact on student engagement. In two of these studies, the impact was described in terms of an Engagement-Achievement Paradox (Shernoff & Schmidt, 2008) and an Effort-Outcome Gap (Greene et al., 2008) as significant differences were found with respect to race, especially for African-American students. While engagement did not translate into academic achievement in terms of grades, it did have an impact on increased educational persistence. In another study by Kuh et al. (2008), they examined engagement in educationally purposeful activities and first-year GPA in college and persistence to the second year. Differences with respect to race/ethnicity were also considered. For African-American students, engagement increased persistence but not their GPA.

Since the majority of the studies included in the literature review were based on students' self-reporting, the accuracy and reliability of self-reporting information were considered. NSSE (2002) researchers indicated that self-reported data were likely to be valid under various conditions such as when the information is known to the respondents and when the questions are clear. However, Porter et al. (2011) refuted the validity and reliability of NSSE with respect to its academic challenge questions on matters of comprehension, recall, judgment and response. Various student survey responses were also compared with transcripts and course syllabi. Overall findings indicated low correlations between actual and self-reported data. However, Laing et al. (1988) found a high level of accuracy in self-reported data among college-bound high-school students. Comparing information students provided on the Student Profile Section of the ACT with information provided by school staff, overall results showed a high degree of consistency. Similarly, Shaw and Mattern (2009) studied the accuracy of self-reported data for college-bound high-school students. When comparing self-reported GPA on the SAT with school-reported GPA, 52% of responses matched; while, 29% under-reported and 19% over-reported. An examination of the accuracy of self-reporting about grades among college students was also conducted. Cole et al.'s (2012) comparison of self-reported and institution-reported grades was found to be very similar, overall. Yet, it was also found that both high-achieving and low-achieving students tended to over-report low grades.

CHAPTER 3

METHODOLOGY

The purpose of this study was to examine the impact of multicultural science education, multimedia, and individual characteristics on under-represented students' engagement in science learning. The investigation was conducted using a quasi-experimental research design and statistical analysis for interpretation of results. In this chapter, the research design, research questions and hypotheses; sample, instrumentation, reliability of the subscales; procedure and data analysis are presented for the study.

Research Design

The study employed a non-equivalent (pretest posttest) group design (NEGD), a type of quasi-experimental methodology.

M----------O----------X----------O

- -

NM---------O---------------------O

As the design indicates, participants were not randomly assigned to groups, and therefore, attention was given to selection-bias as a potential threat to internal validity. In the figure, the "M" represents participants in the multicultural or experimental group who received the treatment ("X"), which is the multicultural science education version of the web-based science learning activity called Seeing Yourself in Science (SYIS). The "NM" represents participants in the non-multicultural or control group who used the non-multicultural version. The pretest and posttest signified by "O" represents the Under-represented Students Engagement in Science Surveys (USESS) that was administered.

Research Questions

RQ1: Are there differences in student engagement scores (cognitive, affective, behavioral) by group (multicultural vs. non-multicultural) and by time (pretest vs. posttest)?

RQ2: Are there differences between experimental and control groups on multimedia use ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results")?

RQ3: Is there a relationship between student engagement and multimedia ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results") use?

RQ4: Is student engagement related to individual characteristics such as race/ethnicity, sex, science grades and academic track?

Participants

While there was a pool of 109 participants available for the study in Grades 9, 10, 11 and 12, ninety-four individuals actually participated. However, 76 residual participants were actually represented in the study who were able to be matched at pretest and posttest. All participants had completed at least one secondary science course. All participants were drawn from academic enrichment programs that target minority, first-generation college and/or low-income students. The programs encourage completion of secondary education and enrollment in and graduation from institutions of postsecondary education. These programs were hosted on the campuses of Wichita State University (WSU), the University of Kansas (KU), Missouri State University (MSU), Avila University (AU) and the University of Missouri, Kansas City (UMKC). Students were selected for participation based on the willingness of the respective programs to be involved in the current research. Assignment to either the experimental or control group was also based on campus participation with one exception—the UMKC campus where students were divided between the two groups. Students at the KU, MSU and the first group of students at the UMKC campus were part of the experimental group using the SYIS (multicultural science) version. Students at AU, WSU and the second group of UMKC students were in the control group using the non-multicultural version. Permission from these institutions/programs (Appendix B), participants and participants' parents/guardians (Appendix A) was obtained as well as approval from the Human Subjects Review Board of Andrews University (Appendix B).

Instrumentation

The Underrepresented Students Engagement in Science Survey (USESS), which is an adapted version of the High School Survey of Student Engagement (HSSSE), was used to measure student engagement in science learning at both the pretest and posttest (Appendix C). eSurveysPro was used to recreate the pretest and posttest surveys and to capture the data. This survey development and administration program has strict policies regarding the confidentiality of data and information used in surveys on its servers.

The surveys were divided into three parts:

1. Demographic information (pretest only)
2. Questions modified from the HSSSE
3. Questions modified from the TLT Flashlight Project (posttest only).

Permission was given for the use of both the HSSSE and TLT Flashlight Project resources.

The USESS pretest and posttest had three sections each. There were 15 items in common on both the pretest and the posttest that related to students' levels and types of engagement in science learning. The pretest included demographic questions and gauged participants' levels and types of engagement in science learning with respect to their school science classes. The posttest examined engagement in science learning and the impact of the multimedia usage after both groups completed their respective versions of the online science curriculum.

A 5-point Likert-type scale ranging from *Strongly Agree* (5) to *Strongly Disagree* (1) allowed participants to indicate their levels of engagement. For example, a modified pretest question asked: "Thinking about *a high school science course* you've taken, fill in the best response that comes closest to how you feel about each of the following statements." One corresponding item was: "Received prompt feedback on science activities, assignments, tasks, test/quiz, etc." On the posttest, the modified question asked: "Thinking about *the online science activity*, fill in the best response that comes closest to how you feel about each of the following statements." The corresponding item was the same. Each item also reflected one of the types or subscales of student engagement, namely cognitive, behavioral or affective.

Cognitive engagement is defined in terms of investment in an activity or the task as well as the principle of communicating high expectations to students that they are capable of performing well. It is also associated with the survey item of thinking critically and deeply about science concepts or processes. Cognitive engagement may also result in changes in inner psychological qualities. The behavioral dimension of student engagement has to do with the effort and attention students expend in the work of learning and was related to survey items such as faculty/student contact, active learning, prompt feedback and time-on-task, which are reflected in the various survey items. Student engagement's affective dimension concerns interest in learning or academic tasks and corresponded with survey items such as respect for diverse talents and ways of learning.

The three subscales were examined with regard to reliability. As previously indicated, a 5-point Likert scale was used and, thus, it is important to calculate and report Cronbach's alpha coefficient for internal consistency reliability. George and Mallery (2003) suggest the following rules of thumb for evaluating alpha coefficients: "> .9 Excellent, > .8 Good, > .7 Acceptable, > .6 Questionable, > .5 Poor, < .5 Unacceptable" (George & Mallery, 2003, p. 23). Table 1 shows the reliabilities for the cognitive, affective and behavioral dimensions. At pretest, these reliabilities ranged from .46 to .69. At posttest, reliabilities ranged from .33 to .86. Behavioral posttest scores had "good" reliability. Because the reliability estimates for the cognitive and affective subscales of the USESS were unacceptably low, exploratory factor analyses were conducted to examine the underlying structures for this sample of students. As a result, only the cognitive and behavioral dimensions were retained and were included in the research questions going forward as well as in Chapters 4 and 5.

The posttest had five unique questions from the TLT Group (Teaching, Learning and Technology) Flashlight Project to examine the impact of multimedia use on student engagement. The five questions asked participants to indicate, from *Strongly Agree* to *Strongly Disagree*, the influence of multimedia with respect to five areas:

Table 1

Reliability for USESS Subscales, Pretest and Posttest

Variable	Number of items	Pretest α	Posttest α
Cognitive	3	.46	.33
Affective	3	.51	.42
Behavioral	9	.69	.86

1. The difficulty of completing tasks if the online science activity did not work correctly

2. Their ability to better understand or visualize the physics concepts

3. The adequacy of their individual computer skills

4. Interest in the online science activity compared with at least one school science course taken

5. The immediate results provided in the online science activity.

As previously mentioned, the USESS instrument used to collect data in the current research was adapted from HSSSE. HSSSE is the nation's largest database on student engagement and is appropriate for the study because it is specifically designed to measure student engagement among high-school students, which is the same population targeted in the current study. In addition, the subscales operationalizing student engagement in this study are also reflected in the HSSSE survey items. Furthermore, HSSSE is adapted from the National Survey of Student Engagement (NSSE) for college students and shares the same psychometric properties and qualities, per M. McCarthy (personal correspondence, May 15, 2005). Kuh (2002) indicated that psychometric analyses establish validity and reliability and the vast majority of the instruments' items to "equal or exceed recommended measurement levels" (Kuh, 2002, p. 21). Focus groups and “cognitive test interviews” (Kuh, 2002, p. 20) also gauged respondents’ interpretations of the meaning of items and their tendency to formulate answers to questions similarly. This led to the instruments’ revision prior to its initial use in 2001 (Kuh, 2002).

To address the question of the impact of multimedia use on student engagement, five questions from the item bank of the TLT Group’s (Teaching Learning and Technology) Flashlight Project, especially designed for educational uses of technology, were included. These items explicitly address the principles of communicating high expectations, respect for diverse talent and ways of learning, faculty/student contact, active learning, prompt feedback, and time-on-task associated with the engagement subscales. Through reviews of different versions by experts from five pilot institutions, the Flashlight Project bank of items has established content validity. In addition, face validity was established by pilot institutions with 40 different surveys composed of items from the item bank (Gilbert & Ehrmann, 1998). Focus groups for respondents, faculty, and administrators involved in results interpretation were used to examine all of the teaching and learning items. Furthermore, a benchmark survey created from a standard template from the item bank and tested for validity and reliability has demonstrated, over a substantial time period, “a consistent Cronbach’s alpha of .85-.90” (Gilbert & Ehrmann, 1998, p. 3).

Seeing Yourself in Science—Pilot Study

Two pilot programs were conducted and included high-school students in South Bend, Indiana, and the Kansas City Metropolitan area. Both groups consisted of under-represented students. The two programs served a total of 15 students. The South Bend program served eight students, of whom four were African-American, two were Caucasian, and two were Hispanic; also, the group had five males and three females. The Kansas City program served seven African-American students, of whom five were female and two were male. While the multimedia activity was not as well developed, the emphasis was still on multicultural science education and physics related to two-dimensional projectile motion. These sessions provided an opportunity to test the appropriateness of the USESS. Participant feedback, both oral and written, indicated the experience was interesting and that it kept their attention. Moreover, they did not find the USESS items too difficult to understand.

Procedure

Participants were involved in the study in conjunction with their participation in academic enrichment programs on the campuses of five Midwestern universities. On each campus, the research was conducted during a period of approximately 2 hours. Participants used either the SYIS or non-multicultural version of the multimedia, science curriculum. This original curriculum emphasized physics concepts related to two-dimensional projectile motion and challenged students to learn the concepts needed in order to stop a fictitious meteor strike on the Kansas City Metro area. At the conclusion of the activity, participants learned an actual meteorite struck the city in 1903. The physics concepts and the meteor metaphor were the same for both the treatment or multicultural version and the control group using the non-multicultural version. At the beginning of each of the sessions, an overview of the study's purpose and of the research activity was given. (Efforts were made not to deliberately or inadvertently influence the research outcomes.) Throughout the activity, participants had my guidance and that of three high-school students, who were non-participants, selected and trained by me to assist. A consultant was on-call from off-site to address any technical difficulties, specifically related to the activity. In addition, within both versions of the activity, participants were assisted by a virtual scientist, for example, one of two different Avatars that were embedded in and programmed to help guide participants during the learning experience.

To collect data with regard to student engagement, the USESS pretests and posttests were accessed via links within each version of the activity (Appendix C). The pretest, completed by participants just after the Avatars provided "self" introductions, included demographic questions and gauged participants' levels and types of engagement in science learning with respect to their school science classes. The posttest examined engagement in science learning and the impact of the multimedia usage after both groups completed their respective versions of the online science activity.

During the activity, participants in both groups interacted with a variety of academic tasks such as short-answer questions, projectile launch simulations, and manipulating terms and definitions related to projectile motion in a matching game. They also practiced and solved problems to attempt to prevent the meteor strike. However, the multicultural version that was used by the treatment group endeavored to reflect levels two and three of multiculturalizing science education. The perspectives and contributions of diverse scientists were infused with the development of scientific concepts and discoveries. For level three, since it was not feasible to carry out any social activism with respect to multicultural science education, illustrative examples were substituted and an "equitable learning environment [was] established in the classroom [to] positively support [different] learning styles [with] all science instruction and content . . . purged of all elitism" (National Science Teachers Association, 2001, p. 3).

Data Analysis

Various methodologies were used to analyze the data with respect to the sample and the research questions. Descriptive statistics, including frequencies and percentages, were used to describe categorical data such as participants' individual characteristics as well as the USESS pretest and posttest items (Appendix C). The means and standard deviations were calculated for the research subscales in both the pretest and posttest items. For the 15 questions common to the pretest and posttest and the five unique posttest questions, their mean scores, standard deviations and percentages were also calculated. Descriptive statistics for the subscale means and standard deviations relevant to the two groups of experimental/multicultural versus control/non-multicultural were also conducted. In addition, the data analysis included the following with respect to each of the study's research questions.

Research Question 1

RQ1: Are there differences in student engagement scores (cognitive, behavioral) by group (multicultural vs. non-multicultural) and by time (pretest vs. posttest)?

Two, one-within one-between mixed model analyses of variances (ANOVAs) were conducted in relation to this research question. These ANOVAs facilitated the testing for main effects of the independent variables and for interaction effects. The one-within or repeated-measures design was appropriate as all participants in the study completed pretests and posttests. Therefore, each participant served as their own control, which lent itself to eliminating variance resulting from individual differences. The one-between analyses were conducted to examine the impact of experimental or control groups using either the SYIS or non-multicultural version of the activity, respectively. The one-between analyses also helped to avoid any carryover effects of the repeated-measures design.

Research Question 2

RQ2: Are there differences between experimental and control groups on multimedia use ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results")?

Independent samples *t*-tests were conducted to further examine any differences between the experimental and control groups in student engagement for the five measures of multimedia. The *t*-tests are appropriate to compare the means of the groups to determine if there are significant differences with respect to each of the measures.

Research Question 3

RQ3: Is there a relationship between student engagement and multimedia ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results") use?

Two multiple linear regressions were run pertaining to the five unique questions on the USESS posttest. This is appropriate for examining the relationship between predictor variables ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results”) and the dependent variable—student engagement in science learning. This was done to determine the best predictor(s) of the dependent variable.

Research Question 4

RQ4: Is student engagement related to individual characteristics such as race/ethnicity, sex, science grades and academic track?

Two multiple linear regressions were conducted for the final research question reflecting four items on the USESS pretest. Again, this analysis was used to examine the relationship between students’ individual characteristics and the impact, if any, on levels and types of engagement in science learning.

CHAPTER 4

ANALYSIS OF THE DATA

Various methodologies were used to analyze the data from the Under-represented Students Engagement in Science Survey (USESS) to examine the impact of multicultural science education, multimedia and individual characteristics on students' types and levels of engagement in science learning. Student engagement was measured both at the pretest and posttest time. On the pretest, participants reflected on their learning and engagement in at least one high-school science course. At posttest, participants reflected on their learning and engagement after having used either the multicultural version or the non-multicultural version of the online science multimedia curriculum.

The reported results include a description of the sample. This is followed by an exploratory factor analysis, which resulted in a two-factor (cognitive and behavioral) solution. Descriptive statistics for the study's participants and the means and standard deviations for the 15 common pretest and posttest items by group, both experimental and control, and by whether it was pretest or posttest are also presented. In addition, descriptive statistics are presented, overall and by group, for the five unique questions on the posttest that addressed the impact of the multimedia usage on student engagement in science learning.

The results of the other data analyzed are presented in relation to the study's four research questions. Data related to the first research question were analyzed with two, one-within one-between mixed model analyses of variance (ANOVAs) with a specific emphasis on main and interaction effects, by multicultural science education versus non-multicultural and by pretest versus posttest. Next, independent sample *t*-tests were used to examine differences between the experimental and control groups regarding engagement in science learning on the five measures of multimedia usage, which is related to Research Question 2. Research Question 3 was analyzed with two multiple linear regressions performed to determine the impact of the multimedia (five unique posttest questions) to predict cognitive and behavioral engagement in science learning. Research Question 4 also involved two multiple linear regressions conducted to examine the relationship of participants' individual characteristics to predict student engagement. In addition, zero-order correlations between individual characteristics, which were dummy coded, and the five multimedia usage variables are provided. The chapter concludes with a summary of the major findings.

Description of the Sample

The participants in the study were high-school students enrolled in academic enrichment programs on the campuses of five Midwestern universities. These programs target minority, first-generation college and/or low-income students with a focus on encouraging completion of secondary education and enrollment in and graduation from institutions of postsecondary education. This section provides a description of the participants and a description of the variables.

A convenience sample of 109 students had the opportunity to participate in the study with 94 students volunteering to participate and signing consent forms accordingly. When participants were matched at pretest and posttest, 76 completed both tests, and were represented in the data analysis. Demographic data and engagement in science learning in school were collected from the pretest; while, posttest responses provided data about participants' experiences with either the 41 students who completed the multicultural version or the 35 students who completed the non-multicultural version of the online science curriculum in comparison to science learning in school. Of the 76 who took part in the study, 71% of the participants were female. African-Americans comprised 34% of the participants, followed by Caucasian student participation of 32%. Only 13% of the participants indicated that English was their second language. Eighty percent of the participants reported earning either A's or A/B's for their science classes. Forty-seven percent of the participants took general or general/regular science classes. Ninety-three percent reported they had a computer with Internet at home. Biology was reported as the science course that 63% of the participants had taken, followed by chemistry at 45%. Frequencies and percentages for participant characteristics are presented in Table 2.

Preliminary Analysis

The USESS was originally designed to measure cognitive, affective and behavioral aspects of student engagement. Reliability analysis of these three subscales resulted in acceptable internal consistency reliability only for the behavioral scores, which were > 7.0 for both pretest and posttest. Cronbach's alpha for cognitive and affective scales was 0.5 or less. Therefore, it was suspected that, for this particular sample, affective and cognitive factors might not be clearly delineated. Thus, a series of exploratory factor analyses using principal axis factoring and principal component analysis with both orthogonal, or varimax, and oblique direct oblimin rotations were conducted. After examining the various solutions to the series of analyses, it appeared that a two-factor solution (cognitive and behavioral) from principal component analysis using varimax rotation was the most interpretable and meaningful.

Both the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy, which was .717, and the Bartlett's Test of Sphericity, which was χ^2 (105) = 469.66, p<.001, indicated that inter-correlation coefficients are adequate and the data are factorable.

Based on scree plot evidence, eigenvalues and percentage of variance accounted for, two factors were retained. Factor 1 represents behavioral items and accounts for 30.86% of the rotated total variance, and factor 2 represents cognitive items and accounts for 23.07% of the total variance. The behavioral factor is reflected in such items as receiving feedback on science activities, used the Internet to complete science activities, and being involved in web-based science learning. These items are associated with the effort and attention students expend in the work of learning (Marks, 2000). The cognitive factor consists of items such as understanding information and its meaning, understanding science concepts and their application to daily life, and thinking critically about science problems. These items represent a learner's investment in the activity or tasks (Marks, 2000), changes in inner psychological qualities (Dimitrov et al., 2002), and the communication of high expectations for learning (Chickering & Gamson, 1987). Factor loadings, percentage of variance accounted for, eigenvalues and Cronbach's alpha are reported in Table 3. Although there are several items which had cross-loadings larger than 0.3, they were conceptually consistent with the factor on which they loaded the highest.

Table 2

Frequencies and Percentages for Participant Characteristics

Characteristic	*n*	%
Sex		
Female	54	71
Male	17	22
Race/Ethnicity		
Arabic	1	1
Asian	6	8
Bi-racial	7	9
Black	26	34
Hispanic	6	8
White	24	32
English as first language		
No	10	13
Yes	62	82
Science grades		
A	30	40
A/B	30	40
B	3	4
B/C	9	12
C	1	1
Type of courses		
College	1	1
Gen or Gen/Reg	36	47
Honors	32	42
Computer access		
Computer	3	4
Computer with Internet	65	86
None	5	7
Classes taken		
Anatomy/physiology	6	8
Biology	48	63
Chemistry	34	45
Environmental science	8	11
Physical science	19	25
Physics	29	38
Other	9	12

Table 3

Factor Analysis for Pre- and Post-Survey Items

Item Text	Loadings Behavioral	Loadings Cognitive
Q4. Involved computer- or web-based science learning activity/program.	0.86	
Q1. Received prompt feedback on science activities.	0.80	
Q3. Used the Internet/Web to get information to do or complete a science activity(s).	0.76	
Q8. I learned useful things in the online science activity.	0.67	0.52
Q7. I was made aware of my learning style and how it affects the way I learn.	0.63	0.43
Q2. Had views and/or examples of different cultures, races, religions, genders, political and/or personal beliefs included in science learning.	0.63	
Q10. I received information about educational and/or careers in science or related fields.	0.59	
Q5. I felt supported by the virtual science instructor.	0.51	0.32
Q11. I am more interested in learning activities that involve using computers, technology.	0.47	
Q13. Considering different perspectives on issues related to science concepts and/or the impact of technology/devices, systems, etc. on society/world.		0.80
Q12. Understanding information and its meaning; having it or being able to explain science concepts in words or language familiar with.		0.74
Q6. I am interested in pursuing a science or related career, e.g. physics, engineering, computers, nursing, biology, physician, etc.		0.64
Q14. Think deeply and critically about the science problems, concepts and/or processes.		0.62
Q15. Understanding how science concepts are applicable in everyday life.	0.40	0.59
Q9. I was challenged to do my best work in the online science activity.	0.56	0.59
Eigenvalue	6.33	1.76
% Variance Explained	30.86	23.07
Cronbach's alpha (pretest)	0.76	0.71
Cronbach's alpha (posttest)	0.88	0.73

Descriptive Statistics

Although there were 94 students who initially participated in this study, some dropped out for various reasons and thus did not complete the posttest survey. This resulted in 76 who had complete data. All analyses that follow are based on a sample size of 76, which were 35 in the control group and 41 in the experimental group. Table 4 shows mean, standard deviation, and percentage of agree/strongly agree for each item related to the subscales, both cognitive or behavioral of student engagement. Posttest means are generally higher than pretest means, indicating some changes in participant ratings.

Table 4

Means and Standard Deviations for Survey Pre- and Posttest Questions 1-15

	Pretest (*N*=76)			Posttest (*N*=76)		
Item	*M*	*SD*	%	*M*	*SD*	%
1. Prompt feedback	3.88	0.94	82	4.24	0.77	87
2. Review different cultures	3.53	1.12	57	3.96	0.96	69
3. Internet/Web science assignments	3.99	1.04	83	4.40	0.75	91
4. Web-based science learning activity	3.49	1.26	61	4.48	0.74	93
5. Support by science teacher	3.97	0.92	78	4.19	0.79	80
6. Interest science-related career	3.78	1.24	64	3.89	1.17	61
7. Awareness of learning style	3.73	0.96	68	4.26	0.72	88
8. Useful things in science	4.04	0.96	82	4.27	0.67	92
9. Best work in science courses	4.04	1.04	83	3.99	0.87	72
10. Education or careers in science	3.83	1.01	75	3.81	0.94	61
11. Science activities and computers	3.44	1.15	48	3.97	0.94	71
12. Explain science concepts	3.84	0.91	75	4.03	0.78	80
13. Different perspectives in science	3.66	0.93	66	4.10	0.82	77
14. Science problem-solving	3.82	0.79	73	4.12	0.70	86
15. Science in everyday life	3.88	0.85	78	4.27	0.59	91

Note. % = % agree/strongly agree.

Table 5 shows group means and standard deviations for each of the 15 common survey items at pretest. Fifty-three percent of the means are higher for the experimental group.

Table 5

Group Means and Standard Deviations for Survey Pretest Questions 1-15

	Control (*n*=35)		Experimental (*n*=41)	
Item	*M*	*SD*	*M*	*SD*
1. Prompt feedback	3.91	1.12	3.85	0.76
2. Review different cultures	3.66	1.18	3.43	1.07
3. Internet/Web science assignments	3.74	1.24	4.19	0.78
4. Web-based science learning activity	3.40	1.30	3.56	1.23
5. Support by science teacher	3.86	0.97	4.07	0.88
6. Interest science-related career	3.90	1.22	3.68	1.25
7. Awareness of learning style	3.85	0.88	3.62	1.02
8. Useful things in science	4.03	1.01	4.05	0.92
9. Best work in science courses	4.06	1.06	4.03	1.04
10. Education or careers in science	4.00	0.97	3.69	1.03
11. Science activities and computers	3.37	1.23	3.51	1.09
12. Explain science concepts	3.80	0.93	3.87	0.90
13. Different perspectives in science	3.66	0.91	3.67	0.96
14. Science problem-solving	3.82	0.75	3.83	0.83
15. Science in everyday life	3.94	0.87	3.83	0.83

Note. Total (*N*=76).

Table 6 shows group means and standard deviations for each of the 15 common survey items at posttest. Sixty percent of the means are higher for the experimental group.

Table 6

Group Means and Standard Deviations for Survey Posttest Questions 1-15

	Control (*n*=35)		Experimental (*n*=41)	
Item	*M*	*SD*	*M*	*SD*
1. Prompt feedback	4.29	0.81	4.20	0.74
2. Review different cultures	3.62	1.00	4.24	0.83
3. Internet/Web science assignments	4.32	0.85	4.48	0.67
4. Web-based science learning activity	4.35	0.82	4.58	0.66
5. Support by science teacher	4.23	0.71	4.26	0.85
6. Interest science-related career	3.96	1.12	3.82	1.22
7. Awareness of learning style	4.32	0.85	4.21	0.60
8. Useful things in science	4.26	0.77	4.28	0.59
9. Best work in science courses	3.97	0.92	4.00	0.84
10. Education or careers in science	3.74	0.91	3.86	0.98
11. Science activities and computers	4.02	0.82	3.93	1.03
12. Explain science concepts	4.30	0.79	4.03	0.79
13. Different perspectives in science	4.13	0.74	4.08	0.85
14. Science problem-solving	4.04	0.57	4.18	0.80
15. Science in everyday life	4.12	0.56	4.40	0.55

Note. Total (*N*=76).

Table 7 shows the means and standard deviations for the survey subscales, both behavioral and cognitive, for the control and experimental groups at pretest and posttest. At pretest, the variable with the smallest mean was the control group for behavioral scores (*M* = 3.76, *SD* = 0.69), and the variable with the largest mean was the control group for cognitive scores (*M* = 3.86, *SD* = 0.61). At posttest, the variable with the smallest mean was the control group for cognitive scores (*M* = 4.04, *SD* = 0.57). The variable with the largest mean at posttest was the experimental group for behavioral scores (*M* = 4.22, *SD* = 0.43).

Table 7

Subscale Means and Standard Deviations by Group

		Pretest		Posttest	
Group	Subscale	*M*	*SD*	*M*	*SD*
Control	Cognitive	3.86	0.61	4.04	0.54
	Behavioral	3.76	0.69	4.13	0.60
Experimental	Cognitive	3.82	0.54	4.08	0.55
	Behavioral	3.78	0.49	4.22	0.43

Note. Control (n=35), Experimental (n=41), (N=76).

Table 8 shows the means and standard deviations for the behavioral survey subscale items for the control and experimental groups at pretest. The smallest mean was the control group (M=3.40, SD=1.30) for the web-based science learning activity item. The item with the largest mean was the experimental group (M=4.19, SD=0.78) for the Internet/Web science assignments item.

Table 9 shows the means and standard deviations for the cognitive survey subscale items for the control and experimental groups at pretest. The smallest mean was the control group (M=3.66, SD=0.91) for the different perspectives in science item. The item with the largest mean was the control group (M=4.06, SD=1.06) for the best work in science courses item.

Table 10 shows the means and standard deviations for the behavioral survey subscale for the control and experimental groups at posttest. The smallest mean was the control group (M=3.62, SD=1.00) for the review different cultures item. The item with the largest mean was the experimental group (M=4.58, SD=0.66) for the Web-based science learning activity item.

Table 8

Group Means and Standard Deviations (Behavioral Pretest)

Item	Control (*n*=35)		Experimental (*n*=41)		Total (*N*=76)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Prompt feedback	3.91	1.12	3.86	0.76	3.88	0.94
Review different cultures	3.66	1.18	3.43	1.07	3.53	1.12
Internet/Web science assignments	3.74	1.24	4.19	0.78	3.99	1.04
Web-based science learning activity	3.40	1.30	3.56	1.23	3.49	1.26
Support by science teacher	3.86	0.97	4.07	0.88	3.97	0.92
Awareness of learning style	3.85	0.88	3.62	1.02	3.73	0.96
Useful things in science	4.04	1.01	4.05	0.92	4.04	0.96
Education or careers in science	4.00	1.23	3.69	1.03	3.83	1.01
Science activities and computers	3.37	0.69	3.51	1.09	3.44	1.15
Behavioral Pretest	3.76	0.97	3.78	0.49	3.77	0.58

Table 9

Group Means and Standard Deviations (Cognitive Pretest)

Item	Control (*n*=35)		Experimental (*n*=41)		Total (*N*=76)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Interest science-related career	3.90	1.22	3.68	1.25	3.78	1.24
Best work in science courses	4.06	1.06	4.03	1.04	4.04	1.04
Explain science concepts	3.80	0.93	3.87	0.90	3.84	0.91
Different perspectives in science	3.66	0.91	3.67	0.96	3.66	0.93
Science problem-solving	3.82	0.75	3.83	0.83	3.82	0.79
Science in everyday life	3.94	0.87	3.83	0.83	3.88	0.85
Cognitive Pretest	3.86	0.61	3.82	0.54	3.84	0.57

Table 10

Group Means and Standard Deviations (Behavioral Posttest)

	Control (*n*=35)		Experimental (*n*=41)		Total (*N*=76)	
Item	*M*	*SD*	*M*	*SD*	*M*	*SD*
Prompt feedback	4.29	0.81	4.20	0.74	4.24	0.77
Review different cultures	3.62	1.00	4.24	0.83	3.96	0.96
Internet/Web science assignments	4.31	0.85	4.48	0.67	4.41	0.75
Web-based science learning activity	4.35	0.82	4.58	0.66	4.48	0.74
Support by science teacher	4.23	0.71	4.16	0.85	4.19	0.79
Awareness of learning style	4.32	0.85	4.21	0.60	4.26	0.72
Useful things in science	4.26	0.77	4.28	0.60	4.27	0.67
Education or careers in science	3.75	0.91	3.86	0.98	3.81	0.94
Science activities and computers	4.02	0.82	3.93	1.03	3.97	0.94
Behavioral Post	4.13	0.60	4.22	0.43	4.18	0.51

Table 11 shows the means and standard deviations for the cognitive survey subscale for the control and experimental groups at posttest. The smallest mean was the experimental group (*M*=3.82, *SD*=1.22) for the interest in science-related career item. The item with the largest mean was also the experimental group (*M*=4.18, *SD*=0.80) for the science problem-solving item.

In addition to the 15 questions taken at pretest and posttest, there were five unique questions on the posttest. These questions examined the impact of the multimedia or technology usage on engagement with respect to: "difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results." The question with the lowest overall mean was "inadequate computer skills," with a mean of 2.39 (*SD* = 1.27). The question with the highest overall mean was “immediate results,” with a mean of 4.17 (*SD* = 0.75). Means and standard deviations for the five unique posttest questions are presented in Table 12.

Table 11

Group Means and Standard Deviations (Cognitive Posttest)

	Control (*n*=35)		Exper (*n*=41)		Total (*N*=76)	
Item	*M*	*SD*	*M*	*SD*	*M*	*SD*
Interest science-related career	3.95	1.12	3.82	1.22	3.89	1.17
Best work in science courses	3.97	0.96	4.00	0.84	3.99	0.87
Explain science concepts	4.03	0.79	4.03	0.79	4.03	0.78
Different perspectives in science	4.13	0.79	4.08	0.85	4.10	0.82
Science problem-solving	4.04	0.57	4.18	0.80	4.12	0.70
Science in everyday life	4.12	0.56	4.40	0.58	4.27	0.59
Cognitive Post	4.04	0.57	4.08	0.55	4.06	0.55

Table 12

Means and Standard Deviations for Five Posttest Questions (Multimedia)

Question	*M*	*SD*	% agree/strongly agree
Difficulty completing tasks	2.67	1.23	26
Able to understand	3.97	0.86	77
Inadequate computer skills	2.39	1.27	26
Online science was more interesting	3.57	1.05	52
Immediate results	4.17	0.75	86

Table 13 shows the means and standard deviations for the five unique posttest questions by group. The data show 100% of the means are higher for the experimental group.

Table 13

Means and Standard Deviations for Five Posttest Questions by Groups (Multimedia)

	Control			Experimental		
Question	*M*	*SD*	% agree/ strongly agree	*M*	*SD*	% agree/ strongly agree
Difficulty completing tasks	2.59	1.21	26	2.73	1.27	26
Able to understand	3.88	0.96	77	4.05	0.77	77
Inadequate computer skills	2.19	1.06	26	2.56	1.43	26
Online science was more interesting	3.20	1.03	52	3.88	0.97	52
Immediate results	4.08	0.84	86	4.25	0.66	86

Results Analyzed by Research Question

In addition, the data analysis included the following with respect to each of the study's research questions.

Research Question 1

RQ1: Are there differences in student engagement scores (cognitive, behavioral) by group (multicultural vs. non-multicultural) and by time (pretest vs. posttest)?

In this section, two, one-within one-between ANOVAs are presented that tested for differences to address research question 1. Specifically, main effects and interaction effects were examined.

Cognitive Scores

The first, one-within one-between ANOVA was conducted to assess if the cognitive scores were significantly different by time, group, or the interaction of time and group. Prior to analysis, the assumption of normality was assessed with Kolmogorov Smirnov (KS) tests. The tests were not significant (p = .217 and .402 for pretest and posttest, respectively) and the assumption was met. The assumption of equality of covariance matrices was assessed with a Box's M test. The result of the test was not significant (p = .798); a significant Box's M test would be a p value less than .001 (Pallant, 2007) so the assumption was met.

The results of the ANOVA showed a main effect for time, F (1, 74) = 8.76, p=.004, partial η^2 =.106. The partial eta squared also indicated that time accounted for approximately 11% of the variance in cognitive engagement. All the students improved from pretest (M=3.84, SD=.57) to posttest (M=4.06, SD=.55). There was no significant effect for group, F (1, 74) = 000, p=.991, partial η^2 =.000. The factor by group interaction was not significant, F (1, 74) =.36, p=.551, partial η^2 =.005. These results suggest that although all students' scores changed over time, they did not do so differentially according to group. Results of the ANOVA are presented in Table 14. Figure 1 shows the average score by group and by time.

Behavioral Scores

Again, one-within one-between ANOVA was conducted to assess if the behavioral scores were significantly different by time. Prior to analysis, the assumption of normality was assessed with Kolmogorov Smirnov (KS) tests. The tests were not

Table 14

One-Within One-Between ANOVA for Cognitive Scores by Group and Time

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Within-Subjects			
Time	1.89	1	1.89	8.76	.004	.106
Time*Group	0.08	1	0.08	0.36	.551	.005
Error	15.92	74	0.22			
			Between-Subjects			
Group	<0.01	1	<0.01	<0.01	0.99	
Error	31.47	74	0.43			

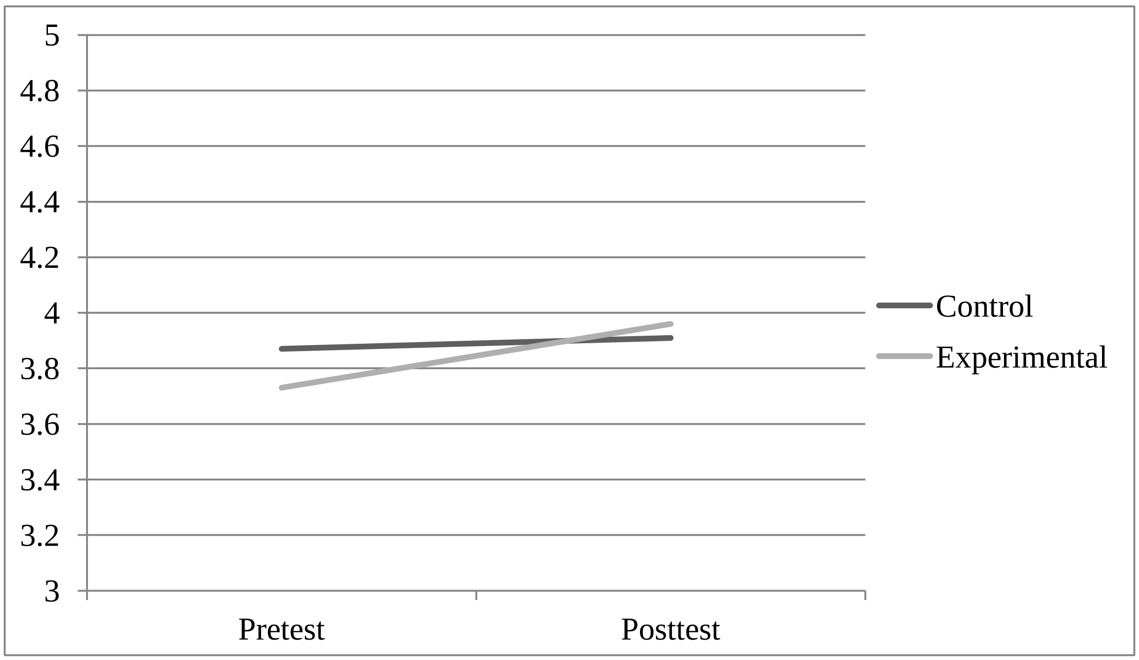

Figure 1. Mean cognitive scores by group and time.

significant (p =.968 and .371 for pretest and posttest respectively) and the assumption was met. The assumption of equality of covariance matrices was assessed with a Box's M test. The result of the test was not significant, p =.035; a significant Box's M test would be a p value less than .001; Pallant, 2007, and the assumption was met.

Results of the ANOVA showed a significant main effect for time, *F* (1, 74) = 19.36, *p*=.000, partial η^2 =.207. The partial eta squared also indicated that time accounted for 21% of the variance in behavioral engagement. All students improved from pretest (*M*=3.76, *SD*=.58) to posttest (*M*=4.18, *SD*=.51). The main effect for group was not significant, *F* (1, 74) =.38, *p*=.542, partial η^2 = .005. The interaction between time and group was not significant, *F* (1, 74) =.14, *p*=.707, partial η^2 = .002. Results of the ANOVA are presented in Table 15. Figure 2 shows the average score by group and time.

Table 15

One-Within One-Between ANOVA for Behavioral Scores by Group and Time

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Within-Subjects			
Time	6.24	1	6.24	19.36	.000	.207
Time*Group	0.05	1	0.05	.143	.707	.002
Error	23.86	74	0.32			
Between-Subjects						
Group	0.11	1	0.11	0.38	.542	.005
Error	21.34	74	0.29			

Research Question 2

RQ2: Are there differences between experimental and control groups on multimedia use ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results")?

Independent sample *t*-tests were conducted to further examine the differences between the experimental and control groups in student engagement for the five measures

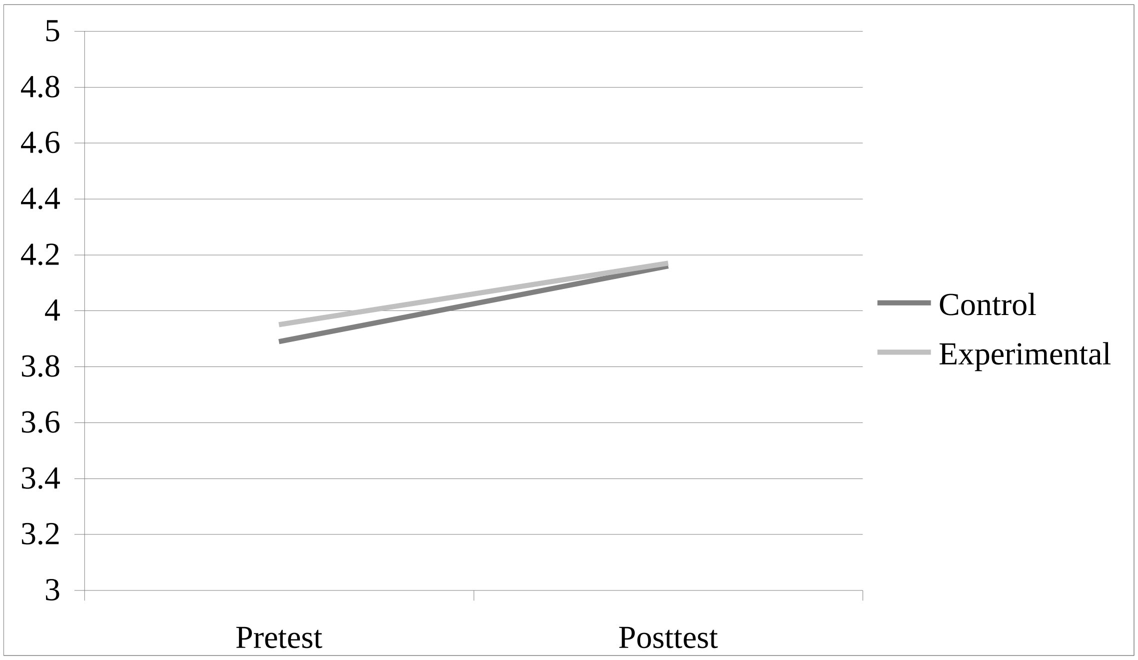

Figure 2. Mean behavioral scores by group and time.

of multimedia at posttest. There was only a significant difference, t (74) = -2.97, p=.004, for the item “online science was more interesting than school science” between the experimental (M=3.88, SD=.97) and control groups (M=3.20, SD=1.03). The results suggest that the experimental group found “online science more interesting” than school science, more so than the control group. In addition, the variable’s corresponding Cohen’s d for effect size was .68. Hence, the magnitude of the difference between the experimental and control groups for the item—online science was more interesting—was moderate (Cohen, 1992). Results of the independent samples t-tests are presented in Table 16.

Table 16

Independent Sample t-Tests

Item	Control (*n*=35)		Experimental (*n*=41)				*ES(d)*
	M	*SD*	*M*	*SD*	*t*	*p*	
Difficulty completing tasks	2.59	1.21	2.73	1.27	- .495	.622	0.11
Able to understand	3.88	0.96	4.05	0.77	-.828	.410	0.20
Inadequate computer skills	2.19	1.06	2.56	1.43	-1.257	.213	0.30
Online science was interesting	3.20	1.03	3.88	0.97	-2.966	.004	0.68
Immediate results	4.08	0.84	4.25	0.66	-1.020	.311	0.23

Research Question 3

RQ3: Is there a relationship between student engagement and multimedia ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results") use?

Two multiple linear regressions were run to address this research question. These regressions pertained to the five unique questions (16, 17, 18, 19 and 20) on the posttest. Prior to each analysis, the assumption of normality was assessed with a p-p scatter plot. The scatter plot showed little deviation from normality and the assumption was met. The assumption of homoscedasticity was assessed with a residuals scatter plot. This scatter plot had values that were rectangularly distributed, and the assumption was met. Variance inflation factors (s) were examined to assess for multicollinearity. Results showed that all VIFs were below 10, meeting the assumption for the absence of multicollinearity. There are nine significant correlations between variables at the $p < 0.01$ level and two at the $p < 0.05$. Among the independent variables, there are three correlations at the $p < 0.01$ level and one correlation at the $p < 0.05$. The data are presented in Table 17.

Table 17

Correlations Among Student Engagement (Cognitive and Behavioral) and Multimedia

				Correlations						
Variable	*n*	*M*	*SD*	1	2	3	4	5	6	7
1. Cognitive	76	4.06	0.55	-	.52**	-.16	.32**	.14	.32**	.25*
2. Behavioral	76	4.18	0.51	-	-	-.03	.50**	-.15	.39**	.55**
3. Diff task	76	2.67	1.23			-	.07	.48**	.08	-.03
4. Understand	76	3.97	0.86				-	-.08	.38**	.41**
5. Comp skills	76	2.39	1.28					-	.11	.04
6. Science Interest	76	3.57	1.05						-	.25*
7. Immediate results	76	4.17	0.75							-

$^*p < .05$. $^{**}p < .01$.

Cognitive Scores

The result of the multiple linear regression was significant, $F(5, 70) = 4.83$, $p = .001$, $R^2 = .26$, suggesting that the linear combination of the five measures of multimedia use accounted for 26% of the variance of the posttest cognitive scores. Further examination showed three statistically significant predictors: “difficulty completing tasks” (B= -0.149, p=.007), “able to understand” (B=0.167, p=.036), and “inadequate computer skills” (B=0.127, p=.017). For every one unit decrease in *not* having “difficulty completing tasks,” cognitive post scores are predicted to be less negative by -0.149 points. Since participants did not have difficulty completing tasks due to the multimedia usage, cognitive engagement is predicted to increase. “Able to understand" was also a significant predictor resulting in a 0.167 point increase in cognitive engagement. As participants were better able to understand and visualize the science ideas and concepts, the prediction was that cognitive engagement would increase.

The other significant predictor of cognitive engagement was "inadequate computer skills," suggesting that for every one unit increase in *not* having inadequate computer skills, cognitive post scores increased by 0.127 points. Since participants were not at a disadvantage using the multimedia due to having inadequate, individual computer skills, it is predicted that cognitive engagement would increase. Of these three significant predictors of cognitive engagement, "difficulty completing tasks" was the most important (β=-.331) followed by "inadequate computer skills" (β=-.293) and "able to understand" (β=.260). These results represent the respective magnitudes or effects on students' cognitive engagement in science learning. Results of the multiple regression are presented in Table 18.

Table 18

Results for Multiple Linear Regression With Five Post Questions Predicting Cognitive Post Scores (Multimedia)

Source	*B*	*SE B*	β	*t*	*p*
Constant	2.90	.038		7.55	.000
Difficulty completing tasks	-.149	.053	-.331	-2.78	.007
Able to understand	.167	.078	.260	2.13	.036
Inadequate computer skills	.127	.052	.293	2.44	.017
Online science was more interesting	.101	.060	.192	1.69	.095
Immediate results	.056	.085	.076	.663	.510

Note. R^2=0.26, $F_{(5, 70)}$ =4.83, p=.001.

Behavioral Scores

The result of the multiple linear regression was significant, F (5, 70)=11.53, p < .000, R^2 = .45, suggesting that the linear combination of the five measures of multimedia use accounted for 45% of the variance in behavioral scores at posttest. Further analysis showed three statistically significant predictors: "able to understand" (B=0.138, p=.029), "online science was more interesting" (B=0.105, p=.031), and "immediate results" (B=0.281, p=.000). For every one unit increase in ability to understand, behavioral scores increased by 0.138 points. As participants were better able to understand and visualize the science ideas and concepts, it was predicted that behavioral engagement would increase. "Online science was more interesting" was also a significant predictor, suggesting that for every one unit increase," behavioral post scores increased by 0.105 points. As participants agreed that online science was more interesting than other school science courses taken, behavioral post scores increased. Therefore, as online science became more interesting, it was predicted that behavioral engagement would increase. In addition, "immediate results" was a significant predictor, suggesting that for every one unit increase, behavioral scores increased by 0.281 points. That is, in providing participants with more immediate results of their work, it was predicted that behavioral engagement would increase. Of these three significant predictors of behavioral engagement, "immediate results" (β=.409) had the greatest influence, followed by "able to understand" (β=.232), and "online science was more interesting" (β =.214). These results represent the respective magnitudes or the effects on students' behavioral engagement in science learning. Results of the multiple linear regression are presented in Table 19.

Table 19

Results for Multiple Linear Regression With Five Post Questions Predicting Behavioral Post Scores (Multimedia)

Source	*B*	*SE B*	β	*t*	*p*
Constant	2.22	.306		7.23	.000
Difficulty completing tasks	.021	.043	.049	.483	.631
Able to understand	.138	.062	.232	2.22	.029
Inadequate computer skills	-.080	.042	-.198	-1.92	.059
Online science was more interesting	.105	.048	.214	2.20	.031
Immediate results	.281	.068	.409	4.16	.000

Note. $R^2 = .45$, $F_{(5, 70)} = 11.53$, p<.000.

Research Question 4

RQ4: Is student engagement related to individual characteristics such as race/ethnicity, sex, science grades or academic track?

Two multiple linear regressions were conducted—using four items (17, 18, 19 and 20) on the individual characteristics of interest to determine if they predicted cognitive and behavioral scores at posttest. All of the individual characteristic categories except sex had multiple levels, which could not be directly entered into the multiple regressions. Therefore, the categorical variables were converted to dichotomous variables. All cases falling into a specific category were assigned the value of "1" if they had that characteristic or "0" if they did not have the characteristic. Sex was coded as female = 0, male = 1. Race was coded as 0 = non-White, 1 = White. Grades in science courses was coded as 0 = not A's and 1 = A's. The type of academic track and science course taken was coded as 0 = non general/regular and 1 = general/regular. In addition, Table 20 provides zero-order correlations between the demographic, or dummy-coded variables, and the five multimedia variables. The results suggest that there is not a linear relationship among the variables.

Table 20

Zero-Order Correlations, Individual Characteristics, and Five Multimedia Variables

Multimedia	Sex	Race	Grades	Type
Difficulty completing tasks	-.17	.02	.13	.00
Able to understand	-.03	.02	.14	.12
Inadequate computer skills	-.06	-.02	-.05	-.03
Online science was more interesting	-.13	.16	.14	.21
Immediate results	.04	.17	.01	.02

Cognitive and Behavioral Scores

None of the scores for individual characteristics was significant. The results of the first regression predicting cognitive scores was not significant, F (4, 57) =.574, p =.682, R^2 =.04, suggesting that individual characteristics did not predict cognitive post scores. The results of the second regression predicting behavioral scores were not significant, F (4, 57) =.576, p =.681, R^2 =.04, suggesting again that individual characteristics did not predict behavioral post scores. Results of the two regressions are presented in Table 21

Summary of Major Findings

Research Question 1

RQ1: Are there differences in student engagement scores (cognitive, behavioral) by group (multicultural vs. non-multicultural) and by time (pretest vs. posttest)?

Table 21

Results for Regressions With Individual Characteristics Predicting Cognitive and Behavioral Scores

DV	IV	*B*	*SE B*	Β	*T*	*P*
Cognitive	Constant	4.01	.120		33.31	.000
	Sex	-.052	.160	-.043	-.325	.747
	Race	-.050	.149	-.044	-.335	.739
	Grades	.189	.146	.174	1.30	.200
	Type	-.126	.148	-.116	-.854	.397
Behavioral	Constant	4.06	.118		34.37	.000
	Sex	.140	.156	.118	.896	.374
	Race	.093	.146	.085	.638	.526
	Grades	.124	.143	.116	.865	.391
	Type	-.108	.145	-.102	-.748	.458

For the one-within one-between ANOVAs, the behavioral and cognitive subscales showed significant main effects for time. Because posttest scores were significantly larger than pretest scores, participants' responses in both the experimental and control groups suggested that both the SYIS and non-multicultural versions of the activity influenced engagement in science learning with respect to the cognitive and behavioral subscales.

Research Question 2

RQ2: Are there differences between experimental and control groups on multimedia use ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results")?

There was a statistically significant difference between the groups on the measure of "online science was more interesting" than school science for the experimental group. The magnitude of the difference between the experimental and control groups was moderate.

Research Question 3

RQ3: Is there a relationship between student engagement and multimedia ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results") use?

Participants in both the experimental and control groups were affected similarly by the multimedia usage. The variance in the five unique posttest items predicted the behavioral and cognitive scores at posttest. Measures of multimedia use accounted for 45% of the variance in posttest behavioral scores and 26% of the posttest cognitive scores. Further examination showed three of the five posttest items were significant predictors of cognitive engagement including: (a) "difficulty completing tasks"; (b) "able to understand"; and (c) "inadequate computer skills." As previously noted, participants indicated that they did not have difficulty completing tasks due to the use of the technology. The prediction is that cognitive engagement would increase among all participants using both the multicultural and non-multicultural versions of the online activity. As the participants indicated that they were better able to understand and visualize the science concepts and ideas and indicated that they had adequate computer skills to participate in the activity, an increase in cognitive scores resulted. Hence, the prediction is that cognitive engagement or investment in science learning would increase among participants using both versions of the online science activity. Three of the five posttest measures were also significant predictors of behavioral engagement including: (a) “able to understand”; (b) “online science was more interesting”; and (c) “immediate results.” As these predictors increase, the prediction was that behavioral engagement, attention, and effort would increase among all participants.

Research Question 4

RQ4: Is student engagement related to individual characteristics such as race/ethnicity, sex, science grades and academic track?

Neither of the two multiple linear regressions conducted to assess whether or not individual characteristics, such as race/ethnicity, sex, science grades or academic track, predicted cognitive and behavioral scores at posttest were found to be significant.

Chapter 5 provides an overview of the problem and purpose of the study. The method, procedure and major findings are presented. The chapter also includes a summary of the study’s main conclusions and offers recommendations for policy and practice and for further research.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

Results from the European-led Organisation for Economic Co-operation and Development's (OECD) International Study of Students and Science Learning showed that while the majority of high-school-aged participants agreed that science helps with understanding the world around them, only 57% agreed that science is personally relevant to them (OECD, 2007). This finding has far-reaching implications, especially for the United States, one of the participating countries, as a significant segment of the population, under-represented students, is under-engaged or disengaged in science education. Moreover, Jackson (2003) asserted that there would be no U.S. talent gap, if certain under-represented groups were adequately represented in science and related fields. Therefore, under-represented students' engagement in science learning is a matter of equity and national interests.

Furthermore, results from the 2000 National Assessment of Educational Progress (NAEP) science assessment and *The Nation's Report Card: Science 2009* (National Center for Education Statistics) also suggest that under-represented and secondary students, in general, are among the most under-engaged or disengaged. These reports also intersect with school effectiveness and student engagement research indicating that student disengagement is particularly pronounced at the secondary level (Busteed, 2013;

Center for Evaluation and Education Policy, 2005; Marks, 2000; Newmann, 1992; Sedlak et al., 1986; Steinberg, 1996; Yazzie-Mintz, 2010).

To improve engagement and to address inequities and national interests where science learning is concerned among under-represented students, more inclusive and/or contemporary curricular and instructional approaches have been recommended. More specifically, Atwater (1996, 2010), Atwater and Riley (1993), Ginovio et al. (2002), Hart and Lee (2003), and Lee (2003) have suggested the needed curricular and instructional reforms lie within multicultural science education to provide "equitable opportunities for *all* students to learn *quality* science" (Atwater, 1996, p. 468, original emphasis).

Multicultural science education facilitates engagement in science learning through "instructional congruence" (Lee, 2003, p. 474) or continuity between students' cultural knowledge and practices and the learning environment (Lee, 2003). Instructional congruence "mediates disciplines, such as science, with students' language and culture to make the academic content accessible and meaningful to students" (Lee, 2003, p. 474). This also indicates that students' individual characteristics must be considered for engagement in learning (Green et al. 2002; Greene et al., 2008; Marks, 2000; Shernoff & Schmidt, 2008). In addition, Green, Brown and Ramirez (2002) noted that multimedia also should be used as a tool to integrate the principles and practices of multicultural education into learning to engage diverse students.

Purpose of the Study

The purpose of this research study was to examine the impact of multicultural science education, multimedia, and individual characteristics on under-represented students' types and levels of engagement in secondary science learning.

Research Questions

To examine the impact of multicultural science education, multimedia, and individual characteristics on under-represented students' engagement in secondary science learning, the following four research questions were considered. The questions also inform the entirety of the content that follows.

Research Question 1

RQ1: Are there differences in student engagement scores (cognitive, behavioral) by group (multicultural vs. non-multicultural) and by time (pretest vs. posttest)?

Research Question 2

RQ2: Are there differences between experimental and control groups on multimedia use ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results")?

Research Question 3

RQ3: Is there a relationship between student engagement and multimedia ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results") use?

Research Question 4

RQ4: Is student engagement related to individual characteristics such as race/ethnicity, sex, science grades or academic track?

Method

Participants

A total of 94 participants took part in the study; however, when participants were matched at pretest and posttest, 76 completed both and are represented in the data analysis. Participants were high-school students in Grades 9, 10, 11 and 12 who had completed at least one secondary-level science course. All participants were drawn from academic enrichment programs on the campuses of five Midwestern universities that target minorities, first-generation college and/or low-income students to encourage completion of secondary education and enrollment in and graduation from institutions of post-secondary education. The majority of the participants were female (71%) and in the 10th grade (39%). African-Americans comprised 34% of the participants, followed by Caucasian student participation of 32%. Thirteen percent of the participants indicated that English was not their first language. In regard to grades earned in a science class(es), participants reported A's (40%) or A/B's (40%). Almost half of the participants (47%) took general or general/regular science classes. All but five participants (7%) had a computer with Internet at home. Biology was reported as the science course most participants had taken (63%), followed by chemistry (45%).

Measures

The Under-represented Students Engagement in Science Survey (USESS), adapted from the High School Survey of Student Engagement (HSSSE), was used at pretest and posttest to measure students' engagement in science learning. The pretest and posttest were created using eSurveysPro and were used to capture the data. The USESS surveys had three sections each, with 15 items in common on both that were related to students' levels and types of engagement in science learning in school (pretest) or in the online science curriculum activity (posttest). A 5-point Likert scale from *Strongly Agree* (5) to *Strongly Disagree* (1) allowed participants to indicate their levels of engagement. For example, a modified pretest question asked: "Thinking about *a high school science course* you've taken, fill in the best response that comes closest to how you feel about each of the following statements." One of the corresponding item choices was: Received prompt feedback on science activities, assignments, tasks, test/quiz, etc. On the posttest, the modified question asked: "Thinking about *the online science activity*, fill in the best response that comes closest to how you feel about each of the following statements." The corresponding item choice was the same. Each item also reflected one of the types or subscales of student engagement related to the cognitive or behavioral dimensions.

Cognitive engagement was defined with respect to inner psychological qualities and was conceptualized in the study as investment in learning or the academic tasks. It also relates to communicating high expectations to students about being capable of performing well. The behavioral dimension of student engagement has to do with the effort and attention students expend in the work of learning as well as faculty/student contact, active learning, prompt feedback and time-on-task, which are reflected in the various survey items.

The posttest had five unique questions from the TLT Group (Teaching, Learning and Technology) Flashlight Project. These were used to examine the impact of the multimedia use on student engagement. The five questions asked participants to indicate, from *Strongly Agree* to *Strongly Disagree*, the influence of the multimedia with respect to: (a) the difficulty of completing tasks if the online science activity did not work correctly; (b) their ability to better understand or visualize the science concepts; (c) the adequacy of their individual computer skills; (d) interest in the online science activity compared with other science courses taken; and (e) the immediate results provided in the online science activity.

Procedures

Participants were involved in the study in conjunction with their participation in academic enrichment programs on the campuses of five Midwestern universities. On each campus, the research was conducted during a period of approximately 2 hours. Participants used either the multicultural science or the non-multicultural version of the multimedia science curriculum. This original curriculum emphasized physics concepts related to two-dimensional or projectile motion and challenged students to learn the concepts and solve problems related to vertical displacement in order to stop a fictitious meteor strike on the Kansas City Metro area. At the conclusion of the activity, participants learned that an actual meteorite struck the city in 1903. The physics concepts and the meteor strike metaphor were the same for both the treatment group who used the multicultural or Seeing Yourself in Science (SYIS) version and the control group who used the non-multicultural version. At the beginning of each of the sessions, an overview of the study and of the online science learning activity was given. (A concerted effort was made not to influence the research outcomes.) Throughout the activity, participants had my guidance and that of three high-school, non-participating students, who were selected and trained by me to assist. An off-site consultant was also on-call to address any technical difficulties, specifically related to the activity. In addition, within both versions of the activity, participants were assisted by virtual scientists, or two different

Avatars that were embedded in and programmed to guide participants during the learning experience.

To collect data concerning student engagement, the USESS pretest and posttest was accessed via links within both versions of the activity (Appendix C). The pretest, completed by participants just after the Avatars provided “self” introductions, included demographic questions and gauged participants’ levels and types of engagement in science learning with respect to at least one school science class. The posttest examined engagement in science learning and the impact of the multimedia usage after both groups completed their respective version of the online science curriculum.

During the activity, participants in both groups interacted with a variety of academic tasks and activities such as short-answer questions, projectile launch simulations, and manipulating terms and definitions related to projectile motion in a matching game. They also practiced and solved problems to try to prevent a meteor strike. However, the SYIS version used by the treatment group included specific images, cultural references, language, ethical dilemmas, videos and music that were relevant to the students and to differentiate it from the non-multicultural version.

Results

The following presents the major findings for the study by each of the four research questions.

Research Question 1

RQ1: Are there differences in student engagement scores (cognitive, behavioral) by group (multicultural vs. non-multicultural) and by time (pretest vs. posttest)?

There were no significant interaction effects between time and group nor differences between the experimental and control groups on the cognitive and behavioral dimensions of student engagement. However, there were significant main effects for time (pretest to posttest) for both groups. As posttest scores were significantly larger than pretest scores, participants' responses in both groups suggested that both the SYIS and non-multicultural versions of the activity influenced engagement in science learning with respect to the behavioral and cognitive subscales.

Research Question 2

RQ2: Are there differences between experimental and control groups on multimedia use ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results")?

There was a statistically significant difference found between the groups on the one measure of "online science was more interesting" than school science for the experimental group. The magnitude of the difference between the experimental and control groups was considered moderate.

Research Question 3

RQ3: Is there a relationship between student engagement and multimedia ("difficulty completing tasks," "ability to understand," "inadequate computer skills," "online science was more interesting," and "immediate results") use?

Participants in both the experimental and control groups were affected similarly by the multimedia use as all five items seemed to have contributed to increasing cognitive and behavioral engagement in science learning. Cognitive engagement was influenced as participants indicated having sufficient computing skills; not encountering any technical difficulties; and being “better able to understand and visualize the science concepts and ideas” through the multimedia presentation. Outcomes with respect to the behavioral dimension of student engagement suggested increasing engagement as participants were again “better able to understand and visualize the science concepts and ideas;” found the “online science was more interesting” than at least one school science course; and appreciated the opportunity to see the “immediate results” of their work.

Research Question 4

RQ4: Is student engagement related to individual characteristics such as race/ethnicity, sex, science grades or academic track?

None of the individual characteristics of the participants—race/ethnicity, sex, science grades or academic track—was found to influence cognitive or behavioral engagement in science learning.

Discussion of Major Findings

The multicultural science education variable did not have a significant impact on student engagement as the independent variable may not have been sufficiently represented to reflect social constructivism’s idea-based approach. Three potential reasons were considered for this outcome. First, the SYIS curriculum was designed to reflect the three-level model to “multiculturalize” science education (NSTA, 2001, p. 3). However, for level three of multiculturalizing science, the ultimate expectation of transforming science education in a setting (school or community) through social activism was unable to be met. While activities representing level three in the SYIS curriculum were intentionally included, the effort may have been insufficient and the timeframe for a substantive change, too short. Another possibility is that both of the online science learning experiences were so markedly different from school science learning that the multicultural effect was negated. Third, the lack of a significant effect for multicultural science education may have been overshadowed by the very programs in which the study's participants were involved. These programs deliberately endeavor to engage minorities, low-income and first-generation students intellectually as well as culturally. Similarly, Marks's research (2000) found inclusive school reforms that were already in place negated the effects of race/ethnicity on secondary students' engagement in learning.

Nevertheless, since student engagement increased for both groups of participants using their respective versions of the multimedia science curriculum, the research literature that indicates that all students can potentially benefit from more inclusive and/or contemporary pedagogy was found to be significant (Banks, 2002; Edwards, 1999; Gay, 2002; Ginovio et al., 2002; Rodriguez, 2003; Rosebery et al., 1992). In addition, since both groups were engaged cognitively and behaviorally, social constructivism's emphasis on cognitive engagement as key to learning seemed to be supported as did behavioral engagement with respect to an emphasis on how students select to allocate their attention (Csikszentmihalyi, 1990).

The impact of multimedia usage on student engagement in science learning was found to be statistically significant by group and for main effects of time. The experimental group found online science more interesting than school science, and more so than the control group in relation to the multimedia usage. The difference was moderate. The significant difference also may have been influenced by the experimental groups' responses to other survey questions related to gauging participants' levels of interest in learning science with or completing science assignments using technology. Descriptive statistics showed that means scores were consistently higher for the experimental group at both pretest and posttest as they related to other questions about using technology for science learning.

When Chang (2006) and Tsai (2005) integrated technology with science pedagogy within a constructivist framework, there were significant findings based on positive attitudes and perceptions about learning science supported by technology among the high-school-aged participants. Moreover, the significant finding, in the current study, for the experimental group in relation to the multimedia usage also reflects social constructivism’s notion of cognitive tools to support sensory learning and experiential knowledge.

As for main effects of time, there were significant findings at posttest. All five of the multimedia items were found to be significant predictors of both cognitive and/or behavioral scores. These significant outcomes are also indicative of social constructivism’s cognitive tools approach wherein technology is used to assist students with sensory learning experiences and experiential knowledge.

First, participants agreed they did not have difficulty completing tasks with the multimedia usage since there were no technical difficulties throughout the entire data collection process. Therefore, investment, shown in cognitive scores in the online science activity, increased for both groups. This also suggested that students expected the online science activity to be user-friendly and functional.

In addition, the item “better able to understand and visualize the science ideas and concepts” resulted in significant predictions of both cognitive and behavioral scores. Given the short pretest to posttest timeframe, which was approximately 2 hours, the increase in cognitive scores was desired, but was somewhat unexpected. In a similar study, conducted by Dimitrov et al. (2002), alternative uses of technology and the impact on changes in students’ science proficiency resulted in no trend effect found for cognitive development or changes in inner psychological qualities given a short pretest to posttest time period. As to changes in inner psychological qualities in the current research, the emphasis on physics concepts would be considered advanced learning, and since only 38% of the students had taken this type of course, it follows that a new level of investment may have been required by the majority of students to learn the concepts.

Chickering and Ehrmann (1996) have noted that “knowing what you know and don’t know focuses your learning” (p. 3). In order to learn the physics concepts, students were able to interact with them through graphics, simulations, verbiage, and even a matching game further supporting cognitive engagement as well as impacting behavioral scores. The multimedia allowed for the physics concepts to be presented in a variety of forms that respected different ways of learning (Chickering & Gamson, 1987). In addition, Mistler-Jackson and Songer (2000) and Vann-Hamilton (2002), who examined students’ views of learning science with technology, noted that varied and active learning opportunities, and even fun facilitated investment in learning.

On the third measure of multimedia usage, “inadequate computer skills” was also a significant predictor of cognitive scores. Students were invested in the science learning as the majority indicated that they had adequate individual computer skills. Throughout the entire data collection process, there were very few questions from the participants about accessing or navigating the online science activities. In addition, the students had my support and that of three high-school, non-participating assistants. These student assistants helped if there were issues related to accessing or navigating the online science activities. However, while 26% or about 20 students indicated that inadequate computer skills might have been an issue, the short-answer response activities requiring more typing may have challenged some students' abilities.

On the fourth measure of multimedia usage, which was "online science was more interesting" than school science, behavioral scores increased. Both versions of the activity afforded students considerable and varied opportunities to learn and demonstrate an understanding of physics concepts related to two-dimensional projectile motion. The result was increased attention and effort, which has been supported by considerable research involving the use of multimedia to broaden the form of knowledge available to students and to facilitate active and experiential learning (Chickering & Ehrmann, 1996; Chickering & Gamson, 1987; Green et al., 2002; Kim, 2001; Yazzie-Mintz, 2010). Even though students had some exposure to Internet- and/or web-based science learning in high school, results indicated students gave more attention and effort to the online science activity in comparison to at least one school science course they had taken. This was particularly evident within the first group of students at the University of Kansas who used the SYIS version of the activity. At the conclusion, an African-American teenage girl asked if the activity could be an on-going part of the academic enrichment program in which she was participating, as "it was the best thing we've had."

On the fifth measure of multimedia usage, the item of “immediate results” of my work had the largest influence on student engagement resulting for behavioral scores among participants. Effective learning involves opportunities to perform and receive feedback on performance. Accordingly, the online science curriculum was deliberately designed to provide immediate feedback for increased guidance for the advanced learning. For example, as students practiced solving the problems related to each step in determining vertical displacement, they were able to check their answers as they went. It was the same during the “Puttin’ It All Together” activity that gave students one last opportunity to solve an entire vertical displacement problem, which would be needed to stop the meteor strike. As previously mentioned, the majority of students had not taken physics so the immediate feedback was especially critical.

For the final variable of individual characteristics examined, no significant differences were found and, therefore, none of the demographic variables of sex, race/ethnicity, grades, or academic track of school science courses taken influenced cognitive or behavioral engagement. However, since the hypothesis was to examine whether or not individual characteristics would have an impact on student engagement in the study, the outcome was still notable. Differing research studies have made the case both ways for the insignificance or significance of individual characteristics and engagement. For example, Elmore and Huebner’s research (2010) showed that student satisfaction with school affected student engagement but race, gender and SES were not significant. Marks (2000) found race/ethnicity was not significant due to school reforms related to inclusivity that were already in place, but SES had a significant impact on high-school students’ engagement in learning. Yazzie-Mintz’s (2010) findings showed a significant difference with respect to high-school students' engagement based on gender and race. An "engagement gap" (p. 17), identified in his analyses of the 2009 HSSSE results, indicated that males and under-represented minority students reported lower engagement in learning. Additionally, Greene et al. (2008), Kuh et al. (2008), and Shernoff and Schmidt (2008) found race to be significant as African-Americans students, in particular, reported being more engaged than other racial/ethnic groups in learning. Again, while there was no relationship found between individual characteristics and student engagement in the current study, participants were not less or more engaged with respect to sex and race/ethnicity and there was no engagement gap. As previously noted, this outcome also may have been impacted by the programs in which the participants were already involved as they endeavor to engage minorities, low-income and/or first-generation students intellectually and culturally. Moreover, the social context of these programs and the consideration of the sociocultural contexts of the learners in this study are reflected in social constructivism's transactional/situated cognitive approach.

Conclusions

1. Student engagement, cognitive and behavioral, increased for both groups of participants supporting other significant findings that all students could potentially benefit from more inclusive and/or contemporary pedagogies.

2. The experimental group's increased interest in the online science learning in relation to the multimedia usage resulted in a moderate difference and also may have reflected an existing interest in science learning with technology among these participants.

3. Since the participants did not encounter technical difficulties while using either version of the online science curriculum, increased cognitive engagement resulted.

4. As the multimedia was used to present the physics concepts through graphics, simulations, verbiage, animation, and a matching game, participants were better able to understand and visualize the concepts, and cognitive and behavioral engagement resulted.

5. As results showed that individual students had the ability to use computers, there was cognitive engagement in the multimedia science learning experience.

6. Results with respect to the multimedia usage showed online science was more interesting than school science for both groups of participants and behavioral engagement resulted.

7. The analyses showed increased behavioral engagement in the physics-based curriculum in relation to participants being able to immediately see or check the results of their problem solving.

8. Student engagement in science learning was not influenced by participants' individual characteristics; however; neither were participants less or more engaged with respect to race/ethnicity or sex as other research has shown.

Recommendations for Policy and Practice

The current research highlighted student engagement as a viable strategy to increase participation in science learning among under-represented students in secondary education. The U.S. Department of Education's High School Redesign initiative (ED.gov, 2013) also recognizes the need for increased engagement and motivation among high-school students as well as increased participation in science related or science, technology, engineering and mathematics (S.T.E.M.) studies. The Redesign

Initiative, referencing the 2012 Gallup Student Poll, reports a continued decline in student engagement from elementary to high school, at which point only "four of 10 students . . . qualify as engaged" (Busteed, 2013, p. 1). Simultaneously, federal and state policies are also focused on the increased use of technology as a way to improve students' learning experiences. It is estimated that "1.8 million students in 2010," up from "220,000 since 2003," have participated in online learning courses across K-12 classrooms (National Science Board, 2014, pp. 1-41).

Given the alignment of national priorities and the study's emphases and significant findings, there are two recommendations for policy and practice. The first recommendation, especially where under-represented students are concerned, is that student engagement efforts in secondary science education reflect more contemporary and/or inclusive pedagogies that could result in increased opportunities for all students to learn quality science. The second recommendation is to couple contemporary and/or inclusive pedagogy, as appropriate, with technology, which had a significant impact on students' engagement in science learning in the study.

The study emphasized that an alternative pedagogy be integrated with technology to engage under-represented students in learning an advanced science subject—physics. This is opposed to the more prevalent approaches within K-12 education of a low level and highly prescriptive pedagogy, which is often focused on improving standardized test scores. Therefore, "the instruction . . . [received] is often designed to determine what [students] can't do, don't like to do, and see no reason doing" (Renzulli, 2008, p. 1), which is the antithesis of engagement. This also can negatively affect the teachers delivering the instruction. Classroom practice should utilize learned-centered approaches to prepare students with the skills to function effectively in an increasingly pluralistic and knowledge-driven world. These skills, such as the application of information to real-world problems, analyzing information for biases or from which to make predictions, etc., also should be "infused with motivationally rich experiences into the curriculum that will promote engagement, increase enjoyment, and produce a genuine enthusiasm for learning" (Renzulli, 2008, p. 2). As previously indicated, the multimedia or use of technology in the current study was used to infuse various motivationally rich experiences into the science-learning curriculum.

These recommendations can be implemented at the classroom or school levels and in out-of-school programs that focus on science or S.T.E.M. learning for a more immediate impact on student engagement. As a result, a model(s) could be developed and tested that is then shared with other key stakeholders also concerned about science-related education and student engagement. Furthermore, these recommendations would also address the fundamental tenant of multicultural science education of providing equitable opportunities for all students to learn quality science as "high engagement results in higher achievement, improved self-concept and self-efficacy, and more favorable attitudes toward school and learning" (Renzulli, 2008, p. 2).

Recommendations for Further Research

While there were significant positive effects on under-represented students' engagement in science learning from the study, there are also some results that necessitate additional research. First, the experimental group, using the multicultural version of the activity, reported more interest in science learning than in school science with the integration of the multimedia. Whether the outcome was influenced by the graphics and the verbal discourse specifically associated with the multicultural science education experience or more so by the multimedia use or some combination of the two requires additional study. Second, the lack of an interaction effect for multicultural science education, which may have been attenuated by factors such as the inability to fully multi-culturalize the online science learning and/or the programs in which the study's participants were enrolled, is worth further research. Therefore, another study integrating a social action theme with science learning and with a larger group of participants not immediately involved in academic enrichment programs, may garner different results.

A second area for additional research is related to individual characteristics and student engagement. Further research might examine the impact of engagement in science learning with respect to participants' socioeconomic status including income levels and/or being part of households where no bachelor degree has been earned.

Another consideration that merits research is the impact of learning style on student engagement. The online science activity was designed with different learning styles in mind and participants were given the opportunity to explore their learning styles with Felder and Soloman's (1991) Index of Learning Styles assessment, but results were not formally measured. Since learning style is an important antecedent of student engagement and matching instruction to students' learning preferences has been shown to increase academic achievement, this variable is also worthy of examination (Center for Evaluation and Education Policy, 2005; Fredericks et al., 2004; Furlong & Christenson, 2008; Yazzie-Mintz, 2010; Zywno, 2002).

APPENDIX A

PARENTAL/PARTICIPANT CONSENT

PARENTAL/PARTICIPANT CONSENT

Andrews University: School of Education, Department of Teaching, Learning and Curriculum

INFORMED CONSENT FORM

Title: *Under-represented Students' Engagement in Science Learning: A Quasi-Experimental Control Group Design*
Project Name: *Seeing Yourself in Science*
Joy Vann-Hamilton, Research Investigator *& PhD Candidate, Curriculum and Instruction; R.J. Ostrander, PhD, Research Supervisor*

Purpose of the Activity: My child/student has the opportunity to take part in the Seeing Yourself in Science activity while participating in the **summer program on the campus of (Missouri State University/the University of Kansas/Avila University/ University of Missouri, Kansas City School of Medicine/Wichita State University)**. The activity involves science concepts related to projectile motion as my student, guided by an avatar, tries to stop a fictitious meteor strike. The activity is part of a research project to learn more about teaching science in ways that may help to increase under-represented, high-school students' interest and engagement in science study and related career fields.

Participation Criteria: The activity is best suited for children/students who are in grades 9, 10, 11 and 12. I also understand that my child/student needs basic computer and calculator skills to be able to participate in the web-based, science activity.

Procedures: My child/student will use a computer provided by **(Missouri State University/ the University of Kansas/Avila University/University of Missouri, Kansas City School of Medicine/Wichita State University)** to access the Internet to participate in the web-based activity. My child/student will create a unique login which will allow him/her to participate in one of two groups (control or experimental group) to participate in the science learning activity. Assistance from the Research Investigator and her assistants and/or program staff will be available to my child/student throughout the activity. The activity is expected to take approximately 1.5 to 2 hours. However, if my child/student is not able to complete the activity based on the allotted time or for some reason misses the activity, s/he can still complete it at his/her convenience until August 3, 2012.

Benefits/Results: My child/student may benefit from participation by having similar science concepts as taught in school reinforced or introduced. My child/student may also benefit as everyday examples, music and videos support the science concepts to make the learning experience relevant and fun, which may encourage him/her to think differently about science learning and related careers.

Risks and Discomforts: I understand there are NO physical, psychological or emotional risks to my child/student by participating in the activity. My child's/student's responses are NOT individualized or graded. Parents/guardians are also welcome to review the activity.

Confidentiality: My child's/student's participation and responses will NOT be shared with or made available to anyone. My child/student will create his/her own log-in to access the web-based, science activity. While the log-in will be associated with my child/student's responses to the various activities, there is no way to specifically identify my child/student. All information will be kept strictly confidential. However, I understand the overall results will be used as part of a research paper but without direct reference to my child/student.

Voluntary Participation: My child's/student's involvement in the activity is voluntary. S/he may fully withdraw or refuse to complete any part or all of the activity at any time without pressure or negative consequences. Participating or not participating in the activity has no impact on participation in the Program of **(Missouri State University/the University of Kansas/Avila University/ University of Missouri, Kansas City School of Medicine/Wichita State University.)**

Consent: I have read the contents of this consent form and have listened to the explanation provided by the Research Investigator and/or the respective program staff. My questions concerning this study have been answered to my satisfaction. I hereby give voluntary consent for my child/student to participate in this study. If I have additional questions or concerns, I may contact Joy Vann-Hamilton by mail at 1800 Washington Blvd., Kansas City, KS 66102 or via phone 816-875-0111 or via email at gtdmultimedia@yahoo.com. Her Research Advisor, Dr. R. J. Ostrander, Professor, Teaching, Learning and Curriculum at Andrews University at rjo@andrews.edu or at Tel: (269) 471-6365 may also be contacted. I have also been given a copy of this consent form.

Parent/Guardian Signature:

____ Date: ____________

Relationship to Child/Student, e.g. mother, father, legal guardian, etc.: ______________

____

Researcher Investigator:

____ Date: ____________

Andrews University: School of Education, Department of Teaching, Learning and Curriculum

STUDENT/PARTICIPANT ASSENT FORM

Title: *Under-represented Students' Engagement in Science Learning: A Quasi-Experimental Control Group Design*
Project Name: *Seeing Yourself in Science*
Joy Vann-Hamilton, Research Investigator *& PhD Candidate, Curriculum and Instruction; R.J. Ostrander, PhD, Research Supervisor*

Purpose of the Activity: I have been told that I have the opportunity to take part in the Seeing Yourself in Science activity while participating in the **summer program on the campus of (Missouri State University/the University of Kansas/Avila University/ University of Missouri, Kansas City School of Medicine/Wichita State University)**. The activity involves science concepts related to projectile motion. An avatar helps me through the activity while I try to stop a fictitious/fake meteor strike. The activity is part of a research project to learn more about teaching science in ways high-school students learn and stay interested in science.

Participation Criteria: I have been told the activity is best for students who are in grades 9, 10, 11 and 12. I also understand that I need basic computer and calculator skills to be able to participate in the web-based, science activity.

Procedures: I have been told that I will use a computer provided by **(Missouri State University/ the University of Kansas/Avila University/University of Missouri, Kansas City School of Medicine/Wichita State University)** to access the Internet to participate in the web-based activity. I will create a unique log-in which will allow me to participate in one of two groups (control or experimental group) to participate in the science learning activity. Assistance from the Research Investigator and her assistants and/or program staff will be available to me throughout the activity. The activity is expected to take approximately 1.5 to 2 hours. However, if I am unable to complete the activity based on the allotted time or for some reason miss the activity, I can still complete it at my convenience until August 3, 2012.

Benefits/Results: I have been told that I may benefit from participation by having similar science concepts, as taught in school, reinforced or introduced. I may also benefit as everyday examples, music and videos support the science concepts to make the learning experience relevant and fun, which may encourage me to think differently about science learning and related careers.

Risks and Discomforts: I have been told there are NO physical, psychological or emotional risks to me by participating in the activity. My responses are NOT individualized or graded. My parents/guardians are also welcome to review the activity.

Confidentiality: My participation and responses will NOT be shared with or made available to anyone. I will create my own log-in to access the web-based, science activity. While the log-in will be associated with my responses to the various activities, there is no way to specifically identify me. All information will be kept strictly confidential. However, I understand the overall results will be used as part of a research paper but without direct reference to me.

Voluntary Participation: My involvement in the activity is voluntary. I may fully withdraw or refuse to complete any part or all of the activity at any time without pressure or negative consequences. Participating or not participating in the activity has no impact on participation in the Program of **(Missouri State University/the University of Kansas/Avila University/ University of Missouri, Kansas City School of Medicine/Wichita State University.)**

Consent: I have read this Assent Form and have listened to the explanation provided by the Research Investigator and/or the respective program staff. My questions concerning this study have been answered to my satisfaction. I hereby give my voluntary consent to participate in this study. If I have additional questions or concerns, I may contact Joy Vann-Hamilton by mail at 1800 Washington Blvd., Kansas City, KS 66102 or via phone 816-875-0111 or via email at gtdmultimedia@yahoo.com. Her Research Advisor, Dr. R. J. Ostrander, Professor, Teaching, Learning and Curriculum at Andrews University at rjo@andrews.edu or at Tel: (269) 471-6365 may also be contacted. I have also been given a copy of this consent form.

Participant/Student Signature:

____ Date: _______________

Researcher Investigator:

____ Date: _______________

APPENDIX B

INSTITUTIONAL APPROVALS

Andrews University
Office of Research & Creative Scholarship

July 10, 2012

Joy Vann-Hamilton
Tel: ((816) 786-1381
Email: willisandjoy@yahoo.com

RE: APPLICATION FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS
IRB Protocol #: 09-113 **Application Type:** Original **Dept.:** Teaching Learning & Curr.
Review Category: Full **Action Taken**: Approved **Advisor:** Ray Ostrander
Title: Underrepresented Students' Engagement in Science Learning: A Quasi-Experimental Control Group Design

This letter is to advise you that the Institutional Review Board (IRB) has reviewed and approved your IRB application for approval of research involving human subjects entitled: *"Underrepresented Students' Engagement in Science Learning: A Quasi-Experimental Control Group Design"* protocol number 09-113 under Full category. This approval is valid until July 10, 2013 If your research is not completed by the end of this period you must apply for an extension at least four weeks prior to the expiration date. We ask that you inform IRB Office whenever you complete your research. Please reference the protocol number in future correspondence regarding this study.

Any future changes made to the study design and/or consent form require prior approval from the IRB before such changes can be implemented.

While there appears to be no more than minimum risk with your study, should an incidence occur that results in a research-related adverse reaction and/or physical injury, this must be reported immediately in writing to the IRB. Any project-related physical injury must also be reported immediately to the University physician, Dr. Hamel, by calling (269) 473-2222.

We wish you success in your research project. Please feel free to contact our office if you have questions.

Sincerely,

Skimakwa

Sarah Kimakwa IRB, Research & Creative Scholarship

AVILA UNIVERSITY

June 22, 2012

Institutional Review Board
Andrews University
4150 Administrative Drive, Room 210
Berrien Springs, MI 49104-0355

Dear Institutional Review Board,

Please accept this letter of institutional consent from the Upward Bound Project of Avila University. My name is Anna McDonald and I serve as the Project Director.

We have agreed to allow Ms. Joy Vann-Hamilton to collect data for her dissertation research entitled, "Underrepresented students' engagement in science learning: a quasi-experimental control group design". She will work with our students during the Summer Institute Program, during which students will use her interactive, multimedia curriculum. Prior to this, she will provide information about the research activity and obtain written consent from participants. Thank you for your attention.

Sincerely,

Ms. Anna McDonald
Project Director
Avila University Upward Bound

Sponsored by the Sisters of St. Joseph of Carondelet

11901 Wornall Road • Kansas City, MO 64145 • 816-942-8400 • Fax 816-942-3362 • www.avila.edu

THE UNIVERSITY OF KANSAS
School of Education

June 4, 2012

Institutional Review Board
Andrews University
4150 Administrative Drive, Room 210
Berrien Springs, MI 49104-0355

Dear Institutional Review Board,

Please accept this letter of institutional consent from the Upward Bound Program of the University of Kansas. My name is Zsashamica Slappy and I serve as the Assistant Director.

We have agreed to allow Ms. Joy Vann-Hamilton to collect data for her dissertation research entitled, "Underrepresented students' engagement in science learning: a quasi-experimental control group design". She will work with our students during the summer institute program, in a 90-minute session, during which students will use her interactive, multimedia curriculum. Prior to this, she will provide information about the research activity and obtain written consent from participants and their parents.

Thank you for your attention.

Sincerely,

Zsashamica Slappy

Ms. Zsashamica Slappy
Assistant Director
University of Kansas

Educational Opportunity Centers, Talent Search, Harvest of Hope Leadership Academy, GEAR UP | Math & Science Center, McNair Scholars Program, Upward Bound Program, Veterans Upward Bound
J R Pearson Hall | 1122 West Campus Road, Room 305 | Lawrence, KS 66045-3101 | (785) 864-3415 | Fax (785) 864-0399 | Toll Free: (877) 842-5232

Missouri State
UNIVERSITY

May 23, 2012
Institutional Review Board
Andrews University
4150 Administrative Drive, Room 210
Berrien Springs, MI 49104-0355

Dear Institutional Review Board,
Please accept this letter of institutional consent from the Upward Bound Program at Missouri State University. My name is TaJuan R. Wilson and I serve as the Director of TRIO Programs.
We have agreed to allow Ms. Joy Vann-Hamilton to collect data for her dissertation research entitled, "Seeing Yourself in Science". She will work with our students in our summer 2012 program in a two-hour session, during which students will use her interactive, multimedia curriculum. Prior to this, she will provide information about the research activity and obtain written consent from participants and their parents at our orientation.
Thank you for your attention.
Yours Respectfully,

TaJuan R. Wilson, MPA
Director, TRiO Programs
Missouri State University
(417) 836-3118
tajuanwilson@missouristate.edu

Office of TRIO PROGRAMS
Upward Bound and Student Support Services
901 South National Avenue*Springfield, Missouri 65897
UB 417-836-3117*SSS 417-836-6220*Fax 417-836-6106
www.missouristate.edu
An Equal Opportunity/Affirmative Action Institution

WICHITA STATE UNIVERSITY
TRIO PROGRAMS
Upward Bound/Math Science

September 10, 2012

Institutional Review Board Andrews University 4150 Administrative Drive, Room 210 Berrien Springs, MI 49104-0355

Dear Institutional Review Board,

Please accept this letter of institutional consent from the Upward Bound Math Science Center at Wichita State University. My name is V. Kaye Monk-Morgan and I serve as the Director of the UBMS program mentioned above.

We have agreed to allow Ms. Joy Vann-Hamilton to collect data for her dissertation research entitled, "Seeing Yourself in Science." She will work with our students in our Academic Year Component 2012 program in a two-hour session, during which students will use her interactive, multimedia curriculum. Prior to this, she will provide information about the research activity and obtain written consent from participants and their parents at our orientation.

Yours Respectfully,

V. Kaye Monk-Morgan Director -Upward Bound Math Science Wichita State University

V. Kaye Monk Morgan

Wichita State University, Wichita, Kansas 67260-0156 Telephone: (316) 978-3316 Toll-Free (800) 531-4984 A TRIO program funded by the U.S. Department of Education in cooperation with Wichita State University
"Preparing for Purpose!"

APPENDIX C

SURVEYS

SEE YOURSELF IN SCIENCE PRETEST

xxx

Seeing Yourself in Science Pre-Survey

SURVEY: This survey asks questions about at least one high school science course(s) -- what your experience has been like, and what you have gained from your class(es) and information about you. (You can NOT be personally identified.) Thank you for your best responses to the following questions.

INSTRUCTIONS: To SELECT the best response, click on the appropriate item/box. (Only one response per question unless otherwise noted.)

CHANGES: To CHANGE a response click on the item/box again to remove your old response, then click on another item/box for your new response.

NOTE: Completion of this survey is completely voluntary. You may exit the survey at any point. You can NOT be identified by your responses and results are STRICTLY CONFIDENTIAL.

Section 1: Thinking about a high science course(s) you've taken, fill in the best response that comes closest to how you feel about the following statements.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Received prompt feedback on science activities, assignments, tasks, test/quiz, etc.	☐	☐	☐	☐	☐
Had views and/or examples of different cultures, races, religions, genders, political and/or personal beliefs included in science learning.	☐	☐	☐	☐	☐
Used the Internet/Web to get information to do or complete a science assignment(s) or activity(s).	☐	☐	☐	☐	☐
Involved computer- or webbased science learning activity/program.	☐	☐	☐	☐	☐

xxx

Seeing Yourself in Science Pre-Survey

Section 2: Thinking about a high science course(s) you've taken, fill in the best response that comes closest to how you feel about the following statements.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
I felt supported by the science instructor.	☐	☐	☐	☐	☐
I am interested in pursuing a science or related career, e.g. physics, engineering, computers, nursing, biology, physician, etc.	☐	☐	☐	☐	☐
I was made aware of my learning style and how it affects the way I learn.	☐	☐	☐	☐	☐
I learned useful things in in a science course(s).	☐	☐	☐	☐	☐
I was challenged to do my best work in a science course(s).					
I received information about educational and/or careers in science or related fields.	☐	☐	☐	☐	☐
I am more interested in learning activities that involve using computers, technology.	☐	☐	☐	☐	☐

Seeing Yourself in Science Pre-Survey

Section 3: Thinking about a high science course(s) you've taken, fill in the best response that comes closest to how you feel about the following statements.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Understanding information and its meaning; having it or being able to explain science concepts in words or language familiar with.	☐	☐	☐	☐	☐
Considering different perspectives on issues related to science concepts and/or the impact of technology/devices, systems, etc. on society/world.	☐	☐	☐	☐	☐
Think deeply and critically about the science problems, concepts and/or processes.	☐	☐	☐	☐	☐
Understanding how science concepts are applicable in everyday life.	☐	☐	☐	☐	☐

XXX

4. What high school or college SCIENCE course(s) have you already taken? (Mark all that apply.)

- [ ] Anatomy & Physiology
- [ ] Biology
- [ ] Chemistry
- [ ] Environmental Science
- [ ] Physical Science
- [ ] Physics
- [ ]

What are or have most of your high school SCIENCE grades been? (Mark only One response.)

- [ ] Mostly As
- [ ] Mixed As & Bs
- [ ] Mostly Bs
- [ ] Mixed Bs & Cs
- [ ] Mostly Cs
- [ ] Mixed Cs and Ds
- [ ] Mostly Ds
- [ ] Below D

Which category represents your SCIENCE class(es)? (Mark only ONE response.)

- [ ] General/Regular
- [ ] Special Education
- [ ] College Credit Courses
- [ ] Honors/College Prep/IB/AP
- [ ] Career/Vocational

Are you male or female?

- [ ] Male
- [ ] Female

What is your racial/ethnic identification? (Mark only ONE response.)

- [ ] Hispanic, Latino/a, or Spanish origin
- [ ] American Indian or other Native American
- [ ] Asian American or Pacific Islander
- [ ] Black/African American
- [ ] White/Caucasian
- [ ] Indian (India)
- [ ] Arabic Descent
- [ ] Jewish
- [ ] Bi-racial
- [ ] Other (Please Specify)

Is English the main language used in your home?

- [ ] Yes
- [ ] No

xxx

If English is not the main language spoken in your home, please type the language in the text box.

What grade are you NOW in, before you go back to school this fall? (Mark only ONE response.)

☐ 9th ☐ 10th ☐ 11th ☐ 12th

What is the name of your high school?

Do you have regular access to a computer or computer with Internet at home?

☐ Computer ☐ Computer and Internet ☐ No

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Finished

SEE YOURSELF IN SCIENCE POSTTEST

xxx

Seeing Yourself in Science Post-Survey

SURVEY: This survey asks questions about the science learning activity you've just completed -- what your experience has been like and what you have gained from it. Thank you for your best responses to the following questions.

INSTRUCTIONS: To SELECT the best response, click on the appropriate item/box. (Only one response per question unless otherwise noted.)

CHANGES: To CHANGE a response click on the item/box again to remove your old response, then click on another item/box for your new response.

NOTE: Completion of this survey is completely voluntary. You may exit the survey at any point. You can NOT be identified by your responses and results are STRICTLY CONFIDENTIAL.

Section 1: Thinking about the online science activity, fill in the best response that comes closest to how you feel about the following statements.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Received prompt feedback on science activities, assignments, tasks, test/quiz, etc.	☐	☐	☐	☐	☐
Had views and/or examples of different cultures, races, religions, genders, political and/or personal beliefs included in science learning.	☐	☐	☐	☐	☐
Used the Internet/Web to get information to do or complete a science assignment(s) or activity(s).	☐	☐	☐	☐	☐
Involved computer- or webbased science learning activity/program.	☐	☐	☐	☐	☐

Seeing Yourself in Science Post-Survey

Section 2: Thinking about the online science activity, fill in the best response that comes closest to how you feel about the statement.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
I felt supported by the virtual science instructor.	☐	☐	☐	☐	☐
I am interested in pursuing a science or related career, e.g. physics, engineering, computers, nursing, biology, physician, etc.	☐	☐	☐	☐	☐
I was made aware of my learning style and how it affects the way I learn.	☐	☐	☐	☐	☐
I learned useful things in the online science activity.	☐	☐	☐	☐	☐
I was challenged to do my best work in the online science activity.					
I received information about educational and/or careers in science or related fields.	☐	☐	☐	☐	☐
I am more interested in learning activities that involve using computers, technology.	☐	☐	☐	☐	☐

Seeing Yourself in Science Post-Survey

Section 3: Thinking about the online science activity, fill in the best response that comes closest to how you feel about the statement.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Understanding information and its meaning; having it or being able to explain science concepts in words or language familiar with.	☐	☐	☐	☐	☐
Considering different perspectives on issues related to science concepts and/or the impact of technology/devices, systems, etc. on society/world.	☐	☐	☐	☐	☐
Think deeply and critically about the science problems, concepts and/or processes.	☐	☐	☐	☐	☐
Understanding how science concepts are applicable in everyday life.	☐	☐	☐	☐	☐

Seeing Yourself in Science Post-Survey

Section 4: Thinking about the online science activity, fill in the best response that comes closest to how you feel about the statement.

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
I missed important information or had difficulty completing tasks because the online science activity did not work correctly.	☐	☐	☐	☐	☐
Using the online science activity, I was better able to understand or visualize the science ideas and concepts.	☐	☐	☐	☐	☐
I was at a disadvantage because I do not have adequate computer skills.	☐	☐	☐	☐	☐
The online science activity was more interesting than other science courses I have taken.	☐	☐	☐	☐	☐
In the online science activity, I was able to see the results of my work almost immediately.	☐	☐	☐	☐	☐

syis.clec-education.com/science/index.htm

Finished

Table 22

Frequencies and Percentages for USESS Survey Questions 1-15

	Pre		Post	
Question	*n*	%	*n*	%
Question 1				
Received prompt feedback on science activities, assignments, task, test/quiz, etc.				
Strongly disagree	2	2	1	1
Disagree	8	9	1	1
Neutral	7	8	7	10
Agree	51	55	32	46
Strongly agree	24	26	29	41
Question 2				
Had view or examples of different cultures, races, religions, genders, political or personal beliefs included in science learning.				
Strongly disagree	5	6	1	2
Disagree	20	22	5	7
Neutral	14	15	15	22
Agree	36	40	22	32
Strongly agree	16	18	25	37
Question 3				
Used the Internet/Web to get information to do or complete science assignment(s) or activity(s).				
Strongly disagree	2	2	1	1
Disagree	9	10	1	1
Neutral	5	6	4	6
Agree	42	46	26	38
Strongly agree	33	36	37	54

Table 22 - Continued.

Question 4				
Used a computer- or web-based science learning program/activity.				
Strongly disagree	8	9	1	1
Disagree	20	22	1	1
Neutral	8	9	3	4
Agree	34	37	23	33
Strongly agree	21	23	41	59
Question 5				
I felt supported by the science instructor(s).				
Strongly disagree	0	0	0	0
Disagree	8	9	2	3
Neutral	13	14	12	17
Agree	42	45	26	38
Strongly agree	30	32	29	42
Question 6				
I am interested in pursuing a science or related career, e.g., engineering, computers, nursing, biology, physician, physicist, etc.				
Strongly disagree	4	5	3	4
Disagree	14	16	7	10
Neutral	14	16	17	24
Agree	15	17	11	16
Strongly agree	42	47	32	46
Question 7				
I was made aware of my learning style and how it affects the way I learn.				
Strongly disagree	1	1	1	1
Disagree	13	14	0	0
Neutral	15	17	7	10
Agree	45	50	33	48
Strongly agree	17	19	28	41

Table 22 - Continued.

Question 8				
I learned useful things in a science course(s).				
Strongly disagree	2	2	0	0
Disagree	5	6	2	3
Neutral	9	10	4	6
Agree	40	44	37	53
Strongly agree	34	38	27	39
Question 9				
I was challenged to do my best work in science.				
Strongly disagree	2	2	1	1
Disagree	7	8	2	3
Neutral	7	8	17	24
Agree	38	42	27	39
Strongly agree	37	41	23	33
Question 10				
I have received information about educational and/or careers in science or related fields				
Strongly disagree	2	2	0	0
Disagree	8	9	7	10
Neutral	12	14	20	29
Agree	40	45	21	30
Strongly Agree	27	30	21	30

Table 22 - Continued.

Question 11				
I am more interested in learning activities that involve using computers, technology.				
Strongly disagree	3	3	0	0
Disagree	20	22	7	10
Neutral	24	27	13	19
Agree	20	22	25	36
Strongly agree	23	26	25	36
Question 12				
Understanding information and its meaning; having it or being able to explain science concepts in words or language familiar with.				
Strongly disagree	2	2	0	0
Disagree	5	6	4	6
Neutral	16	18	10	15
Agree	49	54	35	51
Strongly agree	19	21	20	29
Question 13				
Considering different perspectives on issues related to science and/or the impact of scientific technology/devices, systems, etc. on society/world.				
Strongly disagree	2	2	0	0
Disagree	5	6	3	4
Neutral	24	26	13	19
Agree	44	48	28	40
Strongly agree	16	18	26	37
Question 14				
Thinking deeply and critically about science problem-solving concepts.				
Strongly disagree	0	0	1	1
Disagree	4	4	0	0
Neutral	20	22	9	13
Agree	47	52	39	57
Strongly agree	19	21	20	29

Table 22 - Continued.

Question 15				
Understanding how science concepts are applicable in everyday life.				
Strongly disagree	0	0	0	0
Disagree	7	8	0	0
Neutral	13	14	6	9
Agree	49	54	39	56
Strongly agree	22	24	25	36
Question 16				
I missed important information or had difficulty completing tasks because the online science activity did not work correctly.				
Strongly disagree	-	-	14	19
Disagree	-	-	23	32
Neutral	-	-	16	22
Agree	-	-	11	15
Strongly agree	-	-	8	11
Question 17				
Using the online science activity, I was better able to understand or visualize the science ideas and concepts.				
Strongly disagree	-	-	1	1
Disagree	-	-	4	6
Neutral	-	-	11	16
Agree	-	-	34	49
Strongly agree	-	-	20	29
Question 18				
I was at a disadvantage because I do not have adequate computer skills.				
Strongly disagree	-	-	21	30
Disagree	-	-	26	37
Neutral	-	-	5	7
Agree	-	-	11	16
Strongly agree	-	-	7	10

Table 22 - Continued.

Question 19				
The online science activity was more interesting than other science courses I have taken.				
Strongly disagree	-	-	2	3
Disagree	-	-	10	15
Neutral	-	-	21	30
Agree	-	-	19	28
Strongly agree	-	-	17	25
Question 20				
In the online science activity, I was able to see the results of my work almost immediately.				
Strongly disagree	-	-	0	0
Disagree	-	-	3	4
Neutral	-	-	7	10
Agree	-	-	35	50
Strongly agree	-	-	25	36

REFERENCE LIST

REFERENCE LIST

Archambault, I., Janosz, M., Morizot, J., & Pagani, L. (2009). Adolescent behavioral, affective, and cognitive engagement in school: Relationship to dropout. *Journal of School Health*, *79*(9), 408-415.

Atwater, M. M. (1996). Social constructivism: Infusion into the multicultural science education research agenda. *Journal of Research in Science Teaching, 33*(8), 821-837.

Atwater, M. M. (2010). Multicultural science education and curriculum materials. *Science Activities, 47,* 103-108.

Atwater, M. M., & Brown, M. L. (1999). Inclusive reform: Including all students in the science education reform movement. *The Science Teacher, 66*(3), 44-48.

Atwater, M. M., & Riley, J. P. (1993). Multicultural science education: Perspectives, definitions, and research agenda. *Science Education, 7*(6), 661-668.

Banks, J. A. (1993, September). Multicultural education: Development, dimensions, and challenges. *Phi Delta Kappan, 75,* 22-28.

Banks, J. A. (2002). *An introduction to multicultural education* (3rd ed.). Boston, MA: Allyn and Bacon.

Bredo, E. (1994). Reconstructing educational psychology: Situated cognition and Deweyian pragmatism. *Educational Psychologist*, *29*(1), 23-25.

Busteed, B. (2013, January 7). *Re: The school cliff: Student engagement drops with each school year* [The Gallup Blog]. Retrieved from http://thegallupblog.gallup.com/.

Center for Evaluation and Education Policy. (2005). *High school survey of student engagement: What we can learn from high school students.* Bloomington, IN: Indiana University.

Chang, C-Y. (2006). Effect of the interaction of instructional delivery model and preference of learning environment on students' attitudes. *British Journal of Educational Technology, 37*(5), 799-802. doi:10.1111/j.1467-8535.2006.00603.x

Chickering, A.W., & Ehrmann, S.C. (1996, October). Implementing the seven principles: Technology as a lever. *AAHE Bulletin,* 3-6.

Chickering, A. W., & Gamson, Z. F. (1987). Seven principles for good practice in undergraduate education. *AAHE Bulletin, 39*(7), 3-7.

Clough, E. E., & Driver, R. (1985). Secondary students' conceptions of the conduction of heat: Bringing together scientific and personal views. *Physics Education, 20*, 175-182.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159.

Cole, J. S., Rocconi, L., & Gonyea, R. M. (2012, June 5). *Accuracy of self-reported grades: Implications for research*. Paper presented at the annual meeting of the Association for Institutional Research, New Orleans, LA.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience.* New York, NY: Harper and Row.

Dimitrov, D. M., McGee, S., & Howard, B. C. (2002). Changes in students' science ability produced by multimedia learning environments: Application of the linear logistic model for change. *School Science and Mathematics, 102*(1), 15-24.

D'Souza, D. (1995, November). The crimes of Christopher Columbus. *First Things, 57*, 26-33.

ED.gov. (2013, February 12). *High schools and career readiness: Strengthening the pipeline to the middle class.* Retrieved from http://www.ed.gov/high school.

Edwards, L. D. (1999). *Using multimedia to counter stereotypes in science classrooms: New perceptions of who becomes a scientist.* Houston, TX: National Convention of the Association for Educational Communications and Technology. Retrieved from ERIC database. (ED 436150)

Elmore, G. M., & Huebner, E. (2010). Adolescents' satisfaction with school experiences: Relationships with demographics, attachment relationships, and school engagement behavior. *Psychology in the Schools, 47*(6), 525-537.

Ernest, P. (1999). The nature of mathematics: A social constructivist account. *Science & Education, 78*(7), 674-681.

Felder, R. M., & Soloman, B. A. (1991). *Index of learning styles questionnaire.* Retrieved from http://www.Engr.ncsu.edu/learningstyles/ilsweb.html.

Fetherston, T. (1999). Student constructs about energy and constructivist learning. *Research in Science Education, 29*(4), 515-525.

Finn, J. D. (1989). Withdrawing from school. *Review of Educational Research, 59,* 117-142.

Finn, J. D. (1993). *School engagement and students at risk.* Washington, DC: National Center for Education Statistics.

Fradd, S. H, Lee, O., Sutman, F. X., & Saxton, M. K. (2001). Promoting science literacy with English language learners through instructional materials development: A case study. *Bilingual Research Journal, 25*(4), 479-501.

Fredericks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-109.

Furlong, M. J., & Christenson, S. L. (2008). Engaging students at school and with learning: A relevant construct for *all* students. *Psychology in the Schools*, *45*(5), 365-368. doi: 10.1002/pits.20302

Gay, G. (2002). Preparing for culturally responsive teaching. *Journal of Teaching Education, 53*(2), 106-116.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference, 11.0 update* (4th ed.). Boston, MA: Allyn and Bacon.

Gilbert, S., & Ehrmann, S. C. (1998). *Frequently asked questions about Flashlight.* Retrieved from http://www.tltgroup.org/flashlight/faqs.htm

Ginovio, A. B., Huston, M., Frevert, K., & Siebel, J. B. (2002). The rural girls in science project: From pipelines to affirming science education. *Journal of Women and Minorities in Science and Engineering, 8,* 305-325.

Gredler, M. E. (1997). *Learning and instruction: Theory into practice* (3rd ed.). Upper Saddle River, NJ: Prentice-Hall.

Green, T., Brown, A., & Ramirez, A.Y. (2002). Technology and multiculturalism: A special issue. *Multicultural Education, 10,* 2-48.

Greene, T. G., Marti, C., & McClenney, K. (2008). The effort-outcome gap: Differences for African American and Hispanic community college students in student engagement and academic achievement. *Journal of Higher Education, 79*(5), 513-539.

Haney, J. J., & McArthur, J. (2001). *Four case studies of perspective science teachers' beliefs concerning constructivist teaching practices.* Unpublished manuscript, Department of Educational Curriculum and Instruction, Bowling Green, OH.

Hart, J. E., & Lee, O. (2003). Teacher professional development to improve the science and literacy achievement of English language learners. *Bilingual Research Journal*, *27*(3), 475-500.

Jackson, S. A. (2003). *Changes and challenges in engineering.* Main Plenary. Nashville, TN: American Society for Engineering Education.

Kim, B. (2001). Social constructivism. In M. Orey (Ed.), *Emerging perspectives on learning, teaching, and technology*. Retrieved from http://www.coe.uga.edu/epltt/SocialConstructivism.htm

Kuh, G. D. (2002). *The national survey of student engagement: Conceptual framework and overview of the psychometric properties.* Bloomington, IN: Indiana University, Center for Postsecondary Research and Planning.

Kuh, G. D., Cruce, T. M., Shoup, R., Kinzie, J., & Gonyea, R. M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *Journal of Higher Education*, *79*(5), 540-563.

Laing, J., Sawyer, R., & Noble, J. (1988). Accuracy of self-reported activities and accomplishments of college-bound students. *Journal of College Student Development, 29,* 362-369.

Lee, O. (2003, April). Equity for culturally and linguistically diverse students in science education: A research agenda. *Teachers College Record, 105*(3),465-489.

Lee, O., & Fradd, S. H. (1996). Literacy skills in science learning among linguistically diverse students. *Science Education, 80*(6), 651-671.

Lee, O., & Fradd, S. H. (1998). Science for all, including students from non-English-language backgrounds. *Educational Researcher, 27*(4), 12-21.

Lee, O., & Fradd, S. H. (2001). Instructional congruence to promote science learning and literacy development for linguistically diverse students. In D. R. Lavoie & W-M. Roth (Eds.), *Models for science teacher preparation: Theory into practice* (pp. 109-126). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Lee, O., & Luykx, A. (2006). *Science education and student diversity: Synthesis and research agenda.* New York, NY: Cambridge University Press.

Lynch, S., Kuipers, J., Pyke, C., & Szesze, M. (2005). Examining the effects of a highly rated science curriculum unit on diverse students: Results from a planning grant. *Journal of Research in Science Teaching, 42*(8), 912-946.

Marks, H. M. (2000). Student engagement in instructional activity: Patterns in the elementary, middle, and high school years. *American Educational Research Journal, 37*(1), 153-184.

Mathison, C., & Young, R. (1995). Constructivism and multicultural education: A mighty pedagogical merger. *Multicultural Education: The Magazine of the National Association for Multicultural Education, 2*(4), 7-10.

Matthews, M. (1994). *Science teaching: The role of history and philosophy of science.* New York, NY: Routledge Press.

Mayer, R. E., Moreno, R., Boire, M., & Vagge, S. (1999). Maximizing constructivism learning from multimedia communications by minimizing cognitive load. *Journal of Educational Psychology, 91*(4), 638-643.

McMahon, M. (1997, December). *Social constructivism and the world wide web–A paradigm for learning.* Paper presented at the ASCILITE conference, Perth, Australia. Retrieved from http://www.curtin.edu.au/conference/ASCILITE97/papers/ Mcmahon/Mcmahon.html

Mistler-Jackson, M., & Songer, N. B. (2000). Student motivation and internet technology: Are students empowered to learn science? *Journal of Research in Science Teaching, 37*(5), 459-479.

National Center for Education Statistics. (2011). *The nation's report card: Science 2009 (NCES 2011-450).* Washington, DC: Institute of Education Services, U.S. Department of Education.

National Research Council and the Institute of Medicine. (2003). *Engaging schools: Fostering high school students' motivation to learn.* Washington, DC: The National Academies Press.

National Science Board. (2014). *Science and engineering indicators 2014* (NSB 14-01). Arlington, VA: National Science Foundation.

National Science Teachers Association. (2001). *Science learning for all: Celebrating cultural diversity.* Arlington, VA: NSTA Press.

National Survey of Student Engagement. (2002). *Frequently asked questions about NSSE's psychometric properties.* Retrieved from http://nsse.iub.edu/nsse_2002/faqpsych.cfm?CFID =803d2falee14659

Newmann, F. M. (1992). *Student engagement and achievement in American secondary schools.* New York, NY: Teachers College Press.

Organisation for Economic Co-operational Development. (2007). *PISA 2006: Science competencies for tomorrow's world.* Paris, France: OECD Publishing.

Pallant, J., (2007). *SPSS survival manual: A step-by-step guide to data analysis using SPSS for windows version 15.* New York, NY: McGraw Hill/Open University.

Porter, S. R., Rumann, C., & Pontius, J. (2011). The validity of student engagement survey questions: Can we accurately measure academic challenge? *New Directions for Institutional Research, 2011*(150), 87-98.

Prawat, R. S., & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychologist, 29*(1), 37-48.

Renzulli, J.S. (2008). Engagement is the answer. *Education Week, 27*(43), 30-31. Retrieved from http://www.edweek.org/ew/articles/2008/07/16/43renzulli.h27.html?print=1

Rodriguez, A. J. (2003). "Science for all" and invisible ethnicities: How the discourse of power and good intentions undermine the national science education standards. *Multicultural science education: Theory, practice, and promise.* New York, NY: Peter Lang.

Rosebery, A. S., Warren, B., & Conant, F. R. (1992). Appropriating scientific discourse: Findings from the minority language classroom. *Journal of the Learning Sciences, 21*, 61-94.

Sedlak, M. W., Wheeler, C. W., Pullin, D. C., & Cusick, P. A. (1986). *Selling students short: Classroom bargains and academic reform in the American high school.* New York, NY: Teachers College Press.

Semple, A. (2000). Learning theories and their influence on the development and use of educational technologies. *Australian Science Teachers Journal*, *3*, 21.

Shaw, E. J., & Mattern, K. D. (2009). *Self-reported high school grade point average*. New York, NY: The College Board.

Shernoff, D., & Schmidt, J. (2008). Further evidence of an engagement-achievement paradox among U.S. high school students. *Journal of Youth & Adolescence, 37*(5), 564-580.

Stagg, R. J. (2011). *How inquiry based, social constructivist teaching methodologies can improve the access to and quality of physics education* (Unpublished doctoral dissertation). University of California, Santa Cruz.

Stanley, W. B., & Brickhouse, N. W. (2001). Teaching sciences: The multicultural question revisited. *Science Education, 85*, 35-49.

Staver, J. R. (1998). Constructivism: Sound theory for explicating the practice of science and science teaching. *Journal of Research in Science Teaching*, *35*(5), 501-520.

Steinberg, L. (1996). *Beyond the classroom: Why school reform has failed and what parents need to do.* New York, NY: Simon and Schuster.

Taylor, P. C., Fraser, B. J., & White, L. R. (1994). *An instrument for monitoring the development of constructivist learning environments*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Tsai, C. C. (2005). Preferences toward internet-based learning environments: High school students' perspectives for science learning. *Journal of Educational Technology & Society*, *8*(2), 203-213.

U.S. Department of Education. (2000). *National assessment of educational progress (NAEP)*. Jessup, MD: Institute of Education Sciences, National Center for Education Statistics.

Vann-Hamilton, J. (2002). *My philosophy of educating.* Unpublished manuscript, Andrews University, Berrien Springs, MI.

Walker, C. O., & Greene, B. A. (2009). The relations between student motivational beliefs and cognitive engagement in high school. *Journal of Educational Research*, *102*(6), 463-472.

Weigel, V. B. (2002). *Deep learning for a digital age: Technology's untapped potential to enrich higher education*. San Francisco, CA: Jossey-Bass.

Yazzie-Mintz, E. (2010). *Charting the path from engagement to achievement: A report on the 2009 High School Survey of Student Engagement.* Bloomington, IN: Center for Evaluation & Educational Policy.

Zywno, M.S. (2002). *Instructional technology, learning styles and academic achievement.* Proceedings of the 2002 American Society for Engineering Education Annual Conference and Symposium, Montreal, Quebec, Canada.

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SCHOLARSHIP

Papers, Presentations and Publications:

- Under-represented Students' Engagement in Science Learning: A Non-Equivalent Control-Group Design – dissertation in process
- The 3rd Year's the Charm: FLCs at Notre Dame Get Momentum and Look to the Future - paper accepted, Second International Lilly Faculty Learning Communities Conference, Summer 2004, Miami, OH
- Developing an Online Course: Valuable Lessons Learned, Andrews University, TLC Conference, Spring 2005, Berrien Springs, MI
- From 0 to 6 in 3 Years: Determining Positive Environments for Initiating FLCs - International Faculty Learning Communities Conference, California Poly Technical Institute, Summer 2003, Pomona, CA - panelist
- Developing a Multicultural and Multimedia Engineering Curriculum, Andrews University, TLC Conference, Summer 2003, Berrien Springs, MI
- Delivering Pre-College Engineering Programming Via Two-Way Interactive Video Technology: The Notre Dame Model, National Association of Minority Engineering Program Administrators national conference, Spring 1994, Atlanta, GA - presenter
- The Young African-American Woman and Self-Esteem, Kansas East State Youth Conference, Summer 1995,Topeka, KS – workshop presenter
- Do The Right Thing (Commencement Address), Fort Scott High School, Spring 1995, Fort Scott, KS
- Ameritech Pre-College Minority Engineering Program at Notre Dame, Brochure 1998
- Ameritech Pre-College Minority Engineering Program at Notre Dame Guidebook, 1994
- The Best Brochure of Minority Engineering Students, University of Notre Dame 1994

AWARDS AND HONORS:

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