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Comparison of Student Achievement Using Didactic, Inquiry-Based, and the Combination of Two Approaches of Science Instruction

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Abstract: Science educators and administrators support the idea that inquiry-based and didactic-based instructional strategies have varying effects on students' acquisition of science concepts. The research problem addressed whether incorporating the two approaches covered the learning requirements of all students in science classes, enabling them to meet state and national standards. The optimal teaching method, didactic (teacher-directed), inquiry-based, or a combination of two approaches instructional method, becomes essential if students are to discover ways to learn information. Locally, the results indicated greater and statistically significant differences in standardized laboratory scores for students who were taught using the combination of two approaches. Based on these results, biology instructors will gain new insights into ways of improving the instructional process. Social change may occur as the science curriculum leadership applies the combination of two instructional approaches to improve acquisition of science concepts by biology students.

Keywords: science inquiry methods, science instruction, science teaching methods, didactic teaching methods, traditional teaching methods, didactic learning, constructivism, constructive learning and teaching, technology and science teaching.

1. Introduction

School leadership and the implementation of successful teaching methods will contribute to the cultivation and maintenance of a culture of learning in biology classrooms. Marcum-Dietrich (2008) questioned how the school leadership could find ways to help teachers "break down barriers" (p. 79) that exist so that students might learn science concepts. The presumption is that if science educators and administrators find meaningful ways for students to participate in the learning process then the "ritual of school and the culture of science [would be] easier for [all] students to navigate" (p. 81). The practical application of improving student achievement in science will involve teacher professional development in instructional techniques that align with current technology.

The investigations around this topic included the importance of either didactic or inquiry-based method of instruction but not the simultaneous use of both methods (Estes & Dettloff, 2008; French, 2006; Wilhelm, 2007). In addition to focusing on didactic and inquiry-based methods, this research study explored the efficacy of combining both methods of instruction. As science educators attempt to use data for decision-making related to science curriculum, many factors such as instructional methods and students' pre-existing knowledge affect how students learn and perform in a science class.

The political desire to create a way of "winning the weapons race with the Soviet Union was the premise of the World War II emphasis on science education in the United States" (Spring, 2008, p.394). That proposal resulted in the establishment of the *National Science Foundation (NSF)* in 1950 and the *National Defense Education Act (NDEA)* with the political demand for schools to educate more scientists and engineers. Political advocates of the day, including Senator Vannevar Bush believed that all the problems of the world could be solved through the knowledge and understanding of science (Spring, 2008). As the political issues surrounding science education changed so did the reasons for wanting the population

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to become science literate. As a result, even in recent times, there continues to be support for reform in science education based on those changing and strong political movements.

However, Skoumios and Hatzinikita (2008) suggested that the goal of science teaching was to ensure that students were able to provide support and reasons for answers to scientific questions. The findings of the research that investigated methods to improve students' critical thinking skills advocated that students who engaged in learning through didactic methods did not develop the skills in explaining the reasons behind the answers to questions. As a result, there was an apparent assumption among science educators that they should either focus on hands-on activities, commonly regarded as inquiry instruction, or focus on completing content—direct instruction (Watts, 2005)). The inherent controversy led Robertson (2006) to suggest, "A perceived dichotomy holds sway in science education" (p. 67). The historical debate surrounding the optimal teaching method that will allow student to grasp science concepts continues unabated with no consensus either from research data or from science educators.

The disagreement regarding the best method for teaching science concepts to students dated to the turn of the 20th century when a mathematician who later became a philosopher, argued "No system of external tests which aims primarily at examining individual scholars can result in anything but educational waste" (p. 13). The suggestion indicated that the actual examination used to assess students' acquisition and understanding of science concepts needs to be re-examined with the idea that students are doing inquiry-based learning, and they have to accommodate for the ideas and the eventual reality that their results are not going to fit within the constraints of any examination. It is not clear how or why educators test a student who is contending with information that may be inaccurate in the sense of what we should be anticipating for results while the design of the test looks at perfection, exactly what things should be. So, students learn a subject through inquiry where activities do not happen as planned yet teachers test them according to a perfect scenario which, does not seem realistic (Parini, 2005; Robertson, 2006).

The source of frustration shared among science educators is the constant discussion around reform, but the lack of science reform that comes from the changing political reasons through the years. Those changes have continued with the present-day No Child Left Behind (NCLB) Act (2001). The NCLB Act (2001) was a federal legislation enacted in 2002 to improve standards of teaching and learning for K-12 schools in all states. For states that received federal funding, the government required the development of curricular materials, instructional goals, and assessment methods for testing students (at specific grade levels) to determine acquisition of basic skills in designated subject areas (NCLB, 2001; Southerland, Smith, Sowell, & Kittleson, 2007).

1.1 Didactic Teaching and Learning

Educators often perceive didactic (teacher-directed) instructional method and inquiry to be at opposite ends of the teaching and learning spectrum. The didactic methodology involved presenting the same content to all students, at the same time, and science educators criticized that methodology as not helpful in the process of allowing students to retain science concepts (DeVries & Zan, 2005). That could be the reason that the literature review regarding the use of didactic (teacher-directed) method is sparse as was evident during the research of existing literature sources. Lord and Orkwiszewski (2006) elaborated on the didactic methods of instruction during lab activities and compared the observations with those in inquiry settings. The researchers observed that teachers used a pre-determined method to engage students in laboratory activities in the traditional science classes.

That methodology provided no room for creative input by either the teacher or students. In some cases, students had committed each section of the lab report activity to memory, and knew the expected answers, and where to insert those responses in the laboratory assignment sheets. In contrast, during inquiry lab sessions, students in biology classes developed questions (hypotheses) during discussion sessions and design experiments to prove or disprove those hypotheses. Those findings suggested that students do understand and retain information for substantial period using inquiry methods rather than didactic processes (Lord & Orkwiszewski, 2006). That idea might be one reason for the lack of support for instruction using didactic methods.

However, Estes and Dettloff (2008) emphasized that the didactic method of teaching has its place in educating students but that problems arose with exclusive and excessive use of the methodology. Science educators who use the didactic method of instruction were encouraged to investigate recent research to modify those teaching methods that might allow students to realize increased level of academic achievement. Bland, Saunders, and Frisch (2007) suggested ways to improve didactic method of instruction by asking science educators to engage in preliminary dialogue and suitable humor to gain students' attention. In addition, science educators were encouraged to do less talking and listen more to students' comments. Furthermore, Lang, Drake, and Olson (2006) provided other specific changes that included the use of audits in teaching topics related to ecology that might incorporate teachers, students, and the wider school community.

Above all, those researchers returned to the process of collaboration among designers of thecurriculum to incorporate and provide support for elevating science teaching method within the educational system. Nevertheless, as Lang et al. (2006) put forward, many educators perceive that to cover the volume of information required by the state mandates, in recent years, it was prudent to use only the didactic (teacher-directed) method. As prescribed in the didactic (teacher- directed) method, Bybee and Van Scotter (2006) pointed out that many educators follow the generalized method of identifying a science topic, teaching the topic; finding activities related to the topic that students perform; and deciding how to evaluate student‘s work. That process became the norm for educating students over centuries and teachers who have very little experience with laboratory work continue to use that methodology. In addition, there was poor integration of science laboratories into the science curriculum (Bybee & Van Scotter, 2006). The existing laboratory rooms that contained outdated and ill-equipped resources further compounded the problem.

Many educators who lack those supplies to implement the inquiry method will instead continue to use the more convenient didactic (teacher-directed) method (Oberem & Jasien, 2004); Timmerman, Strickland, and Carstensen (2008) undertook a study to look at curricular reform and inquiry teaching in biology. The study investigated whether students gained knowledge in a more efficient manner through inquiry or didactic methodology. The study involved 1,493 students in introductory biology classes covering various biology concepts. The study revealed that less abstract topics might be taught successfully using didactic methods of instruction. Therefore, the methodology has its place within the instruction process of helping students to grasp scientific information.

Jones (2007) supported the idea that didactic learning and teaching, although condemned by many educators has a role to play in the teaching and learning of science concepts, and proposed that the basis of all science teaching involved engaging students in the learning process. Jones (2007) believed that "tradition and transformation through technology can fruitfully coexist, if we have the will to allow them to do so" (p. 404). To achieve that measure Jones (2007) suggested that educators should find new ways to enhance the didactic method of instruction with debates, technology, and other virtual resources. Those interventions might reduce a passive stance and allow students to actively engage in the instructional process. In addition, the perception was that some educators envisioned the didactic (teacher-directed) method as the best way to have the feeling of being in control of the class. While that perception might be true, some educators used the didactic method because they lacked teacher skills, and because the learners might not have the knowledge needed to establish a scaffold. From the findings of the research by Jones (2007), the didactic method has a role in science instruction and based on the nature of science it might be impossible to eliminate the didactic instructional method from the science classrooms.

1.2 Inquiry Teaching and Learning

The discussions on science teaching strategies of the mid-twentieth century were highlighted when the American Association for the Advancement of Science, 1993 (AAAS); and the National Research Council, 1996, (NRC) called for reform in the science instructional methods. The two institutions advocated for greater incorporation of inquiry instruction into the science teaching methods to allow students greater involvement in the problem-solving process of learning. The researcher believes the reluctance by educators towards implementing such guidelines was that the majority of science educators do not have the necessary opportunity or training needed to support the use of the existing or reformed science curriculum. Not only did science teachers lack the competence, but also many lacked confidence, and the time to expand the innovative teaching techniques that would incorporate inquiry processes into the curriculum to advance students understanding of science concepts (Harwood, Hansen, & Lotter, 2006). Those concerns have continued unabated to the present-day.

French (2006) highlighted those concerns after analyzing a report that included the standards of each state, and the District of Columbia. Further, French (2006) had positive responses to the initiatives to develop standardized methods of assessment, but there were issues with how the report approached inquiry. French (2006) could not support the suggestion that inquiry learning was equivalent to discovery learning and that children could discern and understand the scientific theories without assistance from the teacher. Instead, French (2006) advised that the inquiry process must also “include explaining information, engaging, exploring, extending knowledge to new situations, and evaluating” (p. 60). The researcher asked science teachers to recognize that the inquiry learning process should involve students developing a process through which they internalize the importance of taking ownership for their own learning.

Leshner and Perkins-Bough (2006) supported that idea in a discussion with Steinberg, an eminent university professor of psychology at Temple University, Pennsylvania, United States, to investigate why he became a scientist. Steinberg (2007) explained, “Too much of today‘s science education focuses on making students memorize bits of information that will be outdated within a few years: Too little emphasizes how to think like a scientist” (p. 13). Based on those ideas, the hands-on or method of inquiry teaching and learning that became the beacon for educational reform was supported by other researchers with noted reservations. Manlove, Lazonder, and deJong (2006) tested the effectiveness of including online tool support to assist students through the process of learning science. The findings suggested that the inquiry instructional method that allowed students to formulate their hypotheses, test those hypotheses, and draw conclusions would eventually lead to increased understanding of scientific ideas.

Manlove et al. (2006) expressed the concern that some students would have difficulties with controlling how they learn information to realize any success with inquiry methodology. The proposal suggested that when students used support system such as instructional handouts, their performances were positive. The authors recommended that further research would help other educators to understand whether the support tools would assist in improving students’ acquisition, and allow them to identify, and resolve the difficulties with retaining scientific information. The review might be suggesting that educators should investigate how inquiry instructional methods might be applicable within science classrooms that are accommodating a population of learners with mixed academic abilities.

Science educators continue to struggle with the process of meeting the needs of the range of academic abilities of their students as they facilitate each lesson. With the plethora of learners in any one classroom, many teachers are combining inquiry instructional methods with other science teaching methods. The process is differentiated instruction. “Differentiation begins by recognizing that students start with diverse levels of readiness. Given that reality, the teacher plans instruction to vary content, the way it is learned, and (the) student products” (Estes & Dettloff, 2008, p. 19). Educators who support differentiation methodology have also questioned the relationship among inquiry, differentiated learning, and constructivist learning, and teaching (Sondergeld & Schultz, 2008; Veronesi & Biedlingmaier, 2005). There could be connections between the methodologies, so science educators will need to identify the commonalities and differences, and decide if the differences are worthy of further investigation and implementation.

French (2006) suggested that many science educators perceive that the exceptional influx of new terminologies connected with inquiry learning and teaching do not simplify instruction but create more confusion. Educators may have not fully grasped the principles of the inquiry instructional method and the confusion might come from the common belief that inquiry learning was the same as discovery learning. In working with students, the researcher observed that the process of discovery learning produced an improved level of academic achievement and retention of biological concepts in some learners. However, the inquiry method of teaching and learning does not always produce positive levels of academic achievement in the classroom with students of different learning abilities. Some students may become frustrated and fail to understand or retain the science concepts.

In addition, French (2006) reiterated, "The process must also include explaining information, engaging, exploring, extending knowledge to new situations, and evaluating" (p. 59). Yet, Wee, Shepardson, Fast, and Harbor. (2007) suggested that educators did not have a clear understanding of the meaning of the term inquiry and how to achieve success with inquiry teaching methods in the classroom setting. As a result, many science educators will continue to use their method rather than make any changes in the way they teach without further clarification of the processes that are involved in inquiry teaching and learning.

In an attempt to understand the importance and function of inquiry in the science classroom, Grandy and Duschl (2007) provided a summary of the 2006 National Science Foundation (NSF) sponsored conference. The goals of the conference were to determine how much agreement existed among educators regarding inquiry in science teaching and learning, and to understand how further research and discussion could assist in designing the best environments that would foster inquiry science teaching, and learning. The recommendations from the conference suggested that the newly designed inquiry curriculum should begin at the elementary levels and continue with incremental development through the high school, college, and university levels. As those findings indicated, investigations by educators regarding how to teach science effectively must begin as a collaborative effort between students and teachers at all levels of the educational system. That process should begin from the time students enter formal school until they graduate at the highest levels of learning.

It is noteworthy that the focus of the discussion regarding the most effective method; didactic (teacher-directed), inquiry-based or the combination of two approaches of teaching and learning that might allow students to realize academic achievement in science continues to engage educators at all levels of student education, and that discussion is important to me. As students' progress through our educational system, it is necessary that educators become consistent in deciding the most effective method that will allow students to acquire scientific knowledge and skills to realize enhanced academic levels of achievement. Regassa and Morrison-Shetlar (2007) developed and used a semester-long, inquiry project to engage students in problem-solving and critical thinking skills in an introductory biology course. It was the perception of Regassa and Morrison-Shetlar (2007) that although students enjoyed the hands on laboratory portion of the biology classes, they did not develop the necessary skills to apply the scientific knowledge.

The course evaluations that Regassa and Morrison-Shetlar (2007) produced indicated positive responses to the experimental project methodology by the group of students. The experimental process showed marked changes in students' knowledge and confidence as they took possession of individual work and accepted the changes in the learning environment. Regassa and Morrison-Shetlar (2007) pointed out that there were challenges inherent in using the hands-on process as a tool in inquiry learning. Students resisted the process because teachers asked them to become active participants in the learning process, and to take ownership for their learning. However, the researchers found that while students resisted the new methodology, they became very involved once they recognized their accomplishments. The researcher perceive that if students become involved in developing those skills during high school years, there could be less resistance to engaging in the inquiry process during the move to institutions of higher learning. The findings by Regassa and Morrison-Shetlar (2007) are worthy of continued research to understand how the process will help students as they develop those skills critical to pursuing graduate studies. Those findings also indicated that with the time available for implementation, and under the environmental conditions conducive to inquiry, students could display advanced problem-solving skills while reducing the misconceptions associated with certain biological concepts.

In support of those ideas, Nelson (2008) outlined three strategies that might enhance inquiry instructional methods. The first approach involved the teacher acting as a coach or guide as students exchanged ideas with each other. The second tactic involved helping students to develop critical thinking skills in comparing and contrasting, and the third method would help students to clarify misconceptions that continue to exist between scientific theories and other areas of knowledge. For example, the third stratagem might help to students to reduce their misconceptions when learning controversial topics such as evolution.

While many educators advocate for inquiry method of instruction, the investigator of this research study is concerned with how the inquiry methodology would ensure that students of varying learning abilities could benefit from the inquiry instructional process. The possible answers might come from an examination and evaluation of the connections between the concept of inquiry teaching and learning methods and the constructivist theory.

1.3 Constructivist Teaching and Learning

Under the principles of constructivist learning, the educator must believe that students bring experiences to school from their environment. Those experiences and beliefs should become the "scaffold through which teachers help students attach and assimilate new information" (Reeves, Hammond, & Bradshaw 2004, p. 44). Wilhelm (2007) suggested that science educators should allow students to use those experiences and their peer interactions to describe their understanding of new information. Further investigation of those ideas presented by Wilhelm, (2007) suggested that to engage students in true inquiry, teachers should begin to see themselves as guides rather than instructors, and in that way encourage discussion rather than lecture. The guidelines also encouraged science teachers to use various ways to accomplish the process of inquiry instruction including:

1. making the information relevant to the lives of the students;
2. asking questions that allowed children to think, and they should actively revise and transform each question into a guiding question so that a student's answer would not be simply yes, no, or I do not know;
3. incorporating the questioning techniques into the instructional time since children learn and retain more through doing rather than by listening; and
4. encouraging students to see the information as a mystery to be solved and that might allow the science concepts to "come alive" (Wilhelm, 2007, p. 45).

Those suggestions were authenticated by the observations of Oehlkers and Ruple (2007) through the baking of a pizza that might be considered an unconventional topic and methodology for a teaching science class. However, the observations of Oehlkers and Ruple (2007) showed enhanced levels of active participation by all students during the class activity. Students developed new techniques to ask and answer their own questions compared to "merely reading a text book" (p. 1). Even though there are many issues and concerns with those teaching techniques, the research data continued to advocate for the inquiry method of instruction.

However, Prince and Felder (2007) cautioned that educators needed to be aware of the extensive time and resources needed to realize success with those methods associated with inquiry- based including "problem-based, case-based learning, and just-in-time teaching" (p. 14). The instructional methods will depend on the science qualifications and experience levels of the instructors. The perceptions of many science educators is that it takes too much effort and time, which is limited, to cover the volume of information to meet State mandates as measured by standardized tests (Wood,2005). Consequently, some science educators will use the didactic methodology as their preferred choice of instruction. Finally, Dodick, Argamon, and Chase (2009) suggested that science educators must understand that science instruction and teaching were related to the way scientists actually perform investigations before they attempt to design and develop science curricular material. Once educators gain the suggested understanding, then science educators might overcome one barrier inherent in the inquiry method of instruction.

1.4 The Present Study

This research study compared student achievement in biology based on the use of didactic, inquiry, or the combination of two approaches, during the 2010-2011 academic school year. The information allowed the administrators and science teachers at the girls' high school, in Georgia, U.S.A., to determine which instructional method will provide the best results for students. Mumba and Chitiyo (2008) completed a study of instructional methods used by thirteen science teachers and found that science teachers continue to have trouble with deciding the most effective science teaching methods. In addition, Heppner, Kouttab, and Croasdale (2006) questioned whether the problem with using didactic method and the presentation of the science information to students were related. The decision of which method would provide increased student achievement in science would affect present and future students at the girls' high school, in Georgia, U.S.A., and the wider educational environment.

A study of didactic-based, inquiry-based, and the combination of two approaches determined whether changes in the science teacher‗s pedagogical techniques from lecturing to questioning and collaborating, or a combination of the two was related to students' level of academic achievement in high school biology. This study provided new insights into how the science curriculum leadership in a school might address the teaching techniques of all science courses at this level of students' academic experiences. According to Smerdon, Burkam, and Lee (1999) and Lawson and Johnson (2002), the school leadership has a role in helping teachers determine if the assumption was accurate that hands-on only practices really work better with lower functioning students, while didactic practices worked better with higher functioning students. The idea of incorporating the two instructional methods in most classroom environments was usually presumed to maximize knowledge retention of students having different learning styles (French, 2006; Manlove et al., 2006).

The findings from this research study should be used to develop a comprehensive plan of action regarding science education practices at the girls' high school. That would include an evaluation of students' academic achievement, and educational methods employed by teachers to make the necessary changes that might encourage students to pursue studies in the sciences. In addition, leaders would be encouraged to incorporate the findings of other educational researchers to address the instructional challenges. Rhoton and McLean (2008) suggested that teacher professional development practices should come from observations developed during classroom instructional procedures coupled with differences in the abilities of the learners. Too often, many school leaders see professional development as a process that the organization completes in a 1-day seminar, at the beginning of the school year, with intermittent 30-minute sessions, once or twice, during the school year. It is important that leaders recognize that the leadership involvement within schools has evolved due to historical changes in the educator‗s role that are the result of emerging technological advancements. Consistent and relevant discussions around the issues that affect teachers—teaching and learning—will bring positive changes to how student learn and retain knowledge.

2. Method

2.1 Population and Participants

The investigator of this study taught students at a girls' school in Georgia, U.S.A., from 2006 until 2011, and was a graduate student in Walden University EdD program. A random sampling process was not used; therefore, not every individual in the population had a known chance of being included in the sample. The observation participants were a convenience sample since they were the school‗s certified science teachers. The school community was located in Georgia and the total population of the county was 1,014,932. The racial makeup of the county was 43.8% White, 42.7% Black or African American, 0.19% Native American, 3.04% Asian, 0.04% Pacific Islander, 2.60% from other races, and 1.45% from two or more races (U.S. Census Bureau, 2008). The population of the school community was not an accurate representative of demography of the county. Of the school population, 72% were Caucasian with the remainder classified as African American, Hispanic, and Middle Eastern (Southern Association of College and Schools (SACS) Peer Review Visit, 2008). The geographical distribution of the girls' high school included varying socio economic counties within Georgia, U.S.A.

An evaluation of the 2008 (SACS) data indicated that standardized test results as well as teacher-generated tests and exams denoted relative weakness in mathematical performance (just one of many measure of students‗ performance in science), analysis, and manipulation of language, and in problem-solving skills. Students were assessed using the Educational Records Bureau (ERB) tests in the sixth through tenth grades, the Preliminary SAT (PSAT) in tenth and eleventh grades; SAT I in the eleventh and twelfth grades; and Advanced Placement course in various content areas. Each semester, all students in the high school completed cumulative exams, in all subjects, including science.

2.2 Sampling

The observation participants were certified science teachers of the ninth grade at the high school that consisted of three classes of general biology students for the academic year with no tracking placement. According to the teaching schedules, there were three 50-minute discussion sessions and one 75-minute laboratory period each week for each class. Twenty of the female students entered ninth grade classes after completing courses in earth, life, and physical science in the middle school grades at the girls' school. The other 19 students completed various science courses at other schools in Georgia. All students had varying levels of science knowledge when they entered the ninth grade academic school year. The observation participants were from the population of 180 students and 35 instructors. The sample size whose data used in the analysis consisted of 39 students. To evaluate the size of the treatment effect, the $\eta 2$ was calculated to determine how the differences between the treatments influenced the differences between scores. "The Eta-squared, $\eta 2=$ SS Between/ SS total" (Gravetter & Wallnau, 2008, p. 357) or the―correlation ratio uses,―SS Between that measured variability accounted for by the treatments differences, and SS total that measured the total variability.

2.3 Treatment

The investigator of this study received a Letter of Cooperation from the administrator at the girls' high school and requested that each group of ninth grade students use the same materials and complete the same assignments. In addition, to prevent disruptions to the high school‘s schedule, there was no random assignment of students to different groups (Creswell, 2003). Once the Walden University IRB approval and certificate # 04-18-11-0127882 were received, the investigator of this study made an appointment, in writing, to meet with the potential observation participants. The emails contained several dates and times during which the meeting might take place.

There were six teachers in the science department and three of those, including the investigator of this research study, were instructors of life science and biology. Based on the research study investigation, the investigator of this study selected the two certified teachers of life science and biology to become potential observation participants and use the three instructional methods. As part of each school day, all teachers were able to meet formally or informally between 3:00-3:45 pm, Mondays through Thursdays. Once the mutual meeting time was set up with the observation participants, the investigator of this study explained the nature of the research study, the purpose, the procedures, expected duration, and the benefits and risks of participation. The investigator of this study also informed potential participants of their personal rights to privacy. The potential observation participants were encouraged to ask any questions that might clarify their involvement in the research study. Finally, the investigator of this study asked the potential observation participants to sign and return the teacher informed consent forms within a week to show their willingness to participate in the research study.

The investigator of this study made observations of the study participants 3 times for each of the three groups of students who were taught using didactic-based, inquiry-based, and the combination of two approaches of instruction. Therefore, there were 9 participant observations. Each observation was 75 minutes in duration in the same biology laboratory room. The investigator of this study used a Faculty Observation Rubric during each observation session and recorded personal impressions as soon as each observation was completed. The investigator of this study received permission to use the Faculty Observation Rubric from the creator of the document.

One of the observation participants (Teacher A) holds a master‘s of arts in psychology; master‘s of education in curriculum & instruction (science education); and was involved in doctoral research and design for integration of IPS and chemistry curricula. For more than 6 years, the observed participant taught ninth and tenth grade students in general biology and general and honors chemistry curriculum; grades eleven and twelve students in AP chemistry, biology, and environmental science curriculums; grade seven students in life science curriculum. The second observation participant (Teacher B) holds a master‘s of education in curriculum & instruction (science education). For more than 6 years, the observed participant taught grade nine students in general biology; grades eleven and twelve students in advanced biology, and ecology curriculums; and grade six students in earth science curriculum. Both participants were qualified science instructors who hold certification in the State of Georgia.

In addition, the observed participants were skilled in science curriculum development and wrote curriculum scope and sequences for all courses taught. The investigator of this study chose the colleagues based on those qualifications and skills. During the discussion sessions of the science staff meetings, the investigator of this study perceived that the observed participants had the passion for teaching science and were determined to make needed changes to teaching methods to help students develop an understanding of science concepts. The investigator of this study observed one class (N = 13) that was taught by Teacher A, using the didactic method of instruction where students completed the laboratory experiment and learning occurred using the traditional process. The same content material was "presented to the whole class at once, sometimes with graphic aids like whiteboards or PowerPoint slides and at other times with a demonstration to illustrate a concept" (Estes & Dettloff, 2008, p. 19).

The second class (N = 13) was taught by Teacher B using the inquiry-based method of instruction wherein teacher and class discussions were the primary method, then students completed the laboratory assignments having been given the background information. The third class (N = 13) was taught by Teacher A using a mixture of didactic and inquiry methods, after which the students then completed the laboratory activity. In a 75-minute laboratory session, participants used the didactic method to introduce the major concepts for the initial 15 minutes of the class. For the next 45 minutes, students followed the directions using the handout guides to complete the laboratory activities. Once all students completed the activity, the participants instructed students using the didactic method for 10 minutes to bring closure to the activity. Students then completed the laboratory clean-up in the final five minutes of the session.

The investigator of this study observed as participants repeated the process three times with the three different laboratory activities, where the observation participants varied the method of teaching so that all students were exposed to each proposed method. There was a one-week lapse between each laboratory activity. During the observations, the investigator of this study was not able to determine if there was a transfer of skills on the part of the students. After receiving explicit permission from the cooperating institution, the investigator of this study observed the teacher to identify the three teaching strategies—didactic (teacher-directed), inquiry-based and the combination of two approaches—that were being used and to ensure that any researcher bias would be minimized.

3. Results

The investigator of this study compared the effects of three treatments using ANOVA tests to analyze the research question of the study: *Will there be a statistically significant difference in lab activity scores of three high school biology classes taught using didactic-based instruction, inquiry-based instruction, and the combination of two approaches?*

Each group consisted of 13 students who were exposed to each proposed format. Tables 1, 2, 3, and 4 display the findings from the Group 1 scores; tables 5, 6, 7, and 8 display the findings from the Group 2 scores; and tables 9, 10, 11, and 12 display the findings from the Group 3 scores. For each group, the tables provide the findings for total mean; standard deviation; (SD); standard error (SE); critical F value; Significant (*Sig.*) p value; mean differences at .05 level; and the means for the groups in homogenous subsets.

3.1 Findings for Group 1

The means, standard deviations, and standard errors for the scores were calculated for the three instructional methods for students in Group 1. In Table 1, the total mean for Group 1 was 87.64. The total standard deviation (SD) was 6.62. The standard error (SE) was 1.06. Row 1 represents Method 1 (didactic teaching method), the mean was 84.38. Row 2 presents the mean = 87.23 for Method 2 (inquiry teaching method). Row 3 presents the mean = 91.31 for Method 3 (combination of two approaches.

Table 1 *Group 1 Factor Means, Standard Deviations, and Standard Errors*

Descriptive Statistics for Group 1

Scores	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	13	84.38	7.57	2.10	79.81	88.96	70	96
2	13	87.23	4.95	1.37	84.24	90.22	75	93
3	13	91.31	5.53	1.53	87.97	94.65	81	98
Total	39	87.64	6.62	1.06	85.50	89.79	70	98

For Group 1, Table 2 represents the findings using the single-factor, independent measures analysis of variance (ANOVA) to evaluate the effect of the three teaching methods on the level of student learning achievement in high school biology. The findings indicated that the total sum of squares (*SS*) was 1662.97. The *SS* for *Between* groups was 314.82; and for *Within* groups, *SS*, was 1348.15. The *F* value was 4.20 and the *Sig.* was .023. Significance was measured at the .05 level. The single-factor, independent measures analysis of variance (ANOVA) analysis determined significant difference among the three teaching methods using SPSS 16.0 statistical software, F (2, 36) = 4.20, p =.023. The *F* value obtained indicated that the data supported the alternate hypothesis. There was a statistically significant difference in lab activity scores of students in Group 1 who were taught using didactic-based instruction, inquiry-based instruction, and the combination of two of two approaches.

Table 2 *Group 1 Analysis of Variance (ANOVA) Results*

Group 1 ANOVA Results

	Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Between Groups	314.82	2	157.41	4.20	.023
Within Groups	1348.15	36	37.45		
Total	1662.97	38			

For Group 1, Table 3 presents additional data analyses using the Tukey Honestly Significant Difference (HSD) Post Hoc. Each of the rows represents a comparison of two groups. The first row compares the means for Group1 and Group 2 (-2.85 or 2.85) along with a standard error, *p*-value (―Sig.), .469, SE = 2.40, and a confidence interval. For the second row, the comparison of the means for Group 2 and Group 3, (-4.08 or 4.08) along with a standard error, p value (―Sig.), .220. For the third row, the comparison of the means for Group 3 and Group 1, (-6.92 or 6.92) along with a standard error, p value (―Sig.), .018 (Kirkpatrick & Feeney 2009). The Tukey (HSD) Post Hoc comparisons of the three teaching methods revealed statistically significant difference between the combination of two approaches and didactic instructional methods, $F(2,36) = 4.20$, p = .018. There was no statistically significant difference between the combination of two approaches and inquiry methods of instruction, $F(2,36) = 4.20$, p = .220. There was no statistically significant difference between didactic and inquiry instructional methods, $F(2,36) = 4.20$, p = .469.

Table 3 *Group 1 Tukey Honestly Significant Difference (HSD) Post Hoc Comparison of Instructional Methods*

Descriptive Statistics for Group 1

(I) Teaching Method	J) Teaching Method	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	-2.85	2.40	.469	-8.71	3.02
	3	-6.92*	2.40	.018	-12.79	-1.06
2	1	2.85	2.40	.469	-3.02	8.71
	3	-4.08	2.40	.220	-9.94	1.79
3	1	6.92*	2.40	.018	1.06	12.79
	2	4.08	2.40	.220	-1.79	9.94

Mean difference was significant at the .05 level.

For Group 1, Table 4 identifies the homogenous subsets of means—set of means that do not differ significantly from each other. The left column lists the means for the groups from smallest (Group 1) to the largest mean (Group 3). The two columns to the right list the actual means in subsets. The first subsets contain Groups 1 (mean = 84.38) and 2 (mean = 87.23), while the second subsets contain Groups 3 (mean = 91.31). This indicated that for Groups 1 and 2, the means were not significantly different. However, Group 3 was in a different subset and its mean differed significantly from the means of the groups in subset 1 (Kirkpatrick & Feeney 2009). The eta-squared calculation η^2= SS between/ SS total = % = 314.82/1662.97= .19. Therefore, $F(2, 36) = 3.26$, $p< .05$, = $\eta^2 = .19$.

Table 4 *Tukey Honestly Significant Difference (HSD) Means for Teaching Methods*

Teaching Method	N	Subset for alpha = 0.05 1	2
1	13	84.38	
2	13	87.23	87.23
3	13		91.31
Sig.		.469	.220

Based on the data analyses, the null hypothesis for this study was rejected. There was a statistically significant difference in lab activity scores of the students in Group 1 who were taught using didactic- based instruction, inquiry-based instruction, and the combination of two approaches. This indicated that the means for didactic and inquiry teaching methods were not statistically different = .05, but each was significantly different from the means for the combination of two approaches.

3.2 Findings for Group 2

The means, standard deviations, and standard errors for the scores were calculated for the three instructional methods for students in Group 2. In Table 5, the total mean for Group 2 was 87.74. The total standard deviation (SD) was 7.70. The standard error (SE) was 1.23. Row 1 represents Method 1 (didactic teaching method), the mean was 85.38. Row 2 presents the mean = 85.23 for Method 2 (inquiry teaching method). Row 3 presents the mean = 92.62 for Method 3 (combination of two approaches).

Table 5 *Group 2 Factor Means, Standard Deviations, and Standard Errors*

Descriptive Statistics for Group 2								
Scores	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean			
					Lower Bound	Upper Bound	Minimum	Maximum
1	13	85.38	7.09	1.97	81.10	89.67	70	93
2	13	85.23	9.19	2.55	79.68	90.79	65	98
3	13	92.62	3.82	1.06	90.31	94.92	86	98
Total	39	87.74	7.70	1.23	85.25	90.24	65	98

For Group 2, Table 6 represents the findings using the single-factor, independent measures analysis of variance (ANOVA) to evaluate the effect of the three teaching methods on the level of student learning achievement in high school biology. The findings indicated the total sum of squares (*SS*) was 2255.44. The *SS* for *Between* groups was 462.97; and the *SS Within* groups was 1792.46. The *F* value was 4.65, and the *Sig.* was .016. Significance was measured at the .05 level. The single-factor, independent measures analysis of variance (ANOVA) analysis determined significant difference among the three teaching methods using SPSS 16.0 statistical software, F (2, 36) = 4.65, p = .016. The *F* value obtained indicated that the data supported the alternate hypothesis that there was a statistically significant difference in lab activity scores of students in Group 2 who were taught using didactic-based instruction, inquiry-based instruction, and the combination of two approaches.

Table 6 *Group 2 Analysis of Variance (ANOVA) Results*

Group 2 ANOVA Results					
	Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Between Groups	462.97	2	231.49	4.65	.016
Within Groups	1792.46	36	49.79		
Total	2255.44	38			

For Group 2, Table 7 represents additional data analyses using the Tukey Honestly Significant Difference (HSD) Post Hoc. Each of the rows represents a comparison of two groups. The first row compares the means for Group 1 and Group 2 (.15 or -.15) along with a standard error, *p*-value (―Sig.) .998, SE = 2.77, and a confidence interval. For the second row, the comparison of the means for Group 2 and Group 3, (7.39 or -7.39) along with a standard error, *p* value (―Sig.) .030. For the third row, the comparison of the means for Group 3 and Group 1, (7.23 or -7.23) along with a standard error, p value (―Sig.) .034 (Kirkpatrick & Feeney, 2009). The Tukey HSD Post Hoc comparisons of the three teaching methods revealed that there was statistically significant difference between the combination of two approaches and didactic instructional methods, $F(2,36) = 4.65$, p = .034. There was statistically significant difference between the combination of two approaches and inquiry methods of instruction, $F(2,36) = 4.65$, p = .030. There was no statistically significant difference between didactic and inquiry instructional methods, $F(2,36) = 4.65$, p = .998.

Table 7 *Group 2 Tukey Honestly Significant Difference (HSD) Post Hoc Comparison of Teaching Methods*

Descriptive Statistics for Group 2						
					95% Confidence Interval	Interval I
(I) Teaching Method	(J) Teaching Method	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	.15	2.77	.998	6.61	6.92
	3	-7.23*	2.77	.034	-14.00	-.47
2	1	-.15	2.77	. 998	6.92	6.61
	3	-7.39*	2.77	.030	-14.15	-.62
3	1	7.23*	2.77	.034	.47	14.00
	2	7.39*	2.77	.030	.62	14.15

*. The mean difference is significant at the 0.05 level.

For Group 2, Table 8 identifies the homogenous subsets of means—set of means that do not differ significantly from each other. The left column lists the means for the groups from smallest (Group 1) to the largest mean (Group 3). The two columns to the right list the actual means in subsets. The first subsets contain Groups 1 (mean = 85.23) and 2 (mean = 85.38), while the second subset contains Groups 3 (mean = 92.62). This indicated that for Groups 1 and 2, the means were not significantly different. However, Group 3 was in a different subset and its mean differed significantly from the means of the groups in subset 1 (Kirkpatrick & Feeney, 2009). The eta-squared calculation η^2= SS between/ SS total = % = 462.97/1792.46 = .26. Therefore, $F(2, 36) = 3.26$, $p< .05$, $\eta^2 = .26$.

Table 8 *Tukey Honestly Significant Difference (HSD) Means for Teaching Methods*

Subset for alpha = 0.05

Teaching Method	N	1	2
2	13	85.23	
1	13	85.38	
3	13		92.62
Sig.		.998	1.000

Means for groups in homogeneous subsets are displayed.

Based on the data analyses, the null hypothesis for this study was also rejected. There was a statistically significant difference in lab activity scores of the students in Group 2 who were taught using didactic-based instruction, inquiry-based instruction, and the combination of two approaches. This indicated that the means for didactic and inquiry teaching methods were not statistically different **=.**05, but each was significantly different from the means for the combination of two approaches.

3.3 Findings for Group 3

The means, standard deviations, and standard error for the scores were calculated for the three instructional methods for students in Group 3. In Table 9, the total mean for Group 1 was 87.79. The total standard deviation (SD) was 6.77. The standard error (SE) was 1.08. Row1 represents Method 1 (didactic teaching method), the mean was 84.00. Row 2 presents the mean = 87.54 for Method 2 (inquiry teaching method). Row 3 presents the mean = 91.85 for Method 3 (combination of two approaches).

Table 9 *Group 3: Factor Means, Standard Deviations, and Standard Errors*

Descriptive Statistics for Group 3

					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	13	84.00	8.06	2.24	79.13	88.87	68	90
2	13	87.54	5..78	1.61	84.04	91.03	78	95
3	13	91.85	3.63	1.01	89.66	94.04	85	97
Total	39	87.79	6.77	1.08	85.60	89.99	68	97

For Group 3, Table 10 represents the finding using the single-factor, independent measures analysis of variance (ANOVA) to evaluate the effect of the three teaching methods on the level of student learning achievement in high school biology. The findings indicated the total sum of squares (*SS*) was 1740.40. The *SS* for *Between* groups was 401.44; and for *Within* groups, *SS* was 1338.92. The *F* value was 5.40 and the *Sig.* was .009. Significance was measured at the .05 level. The single-factor, independent measures analysis of variance (ANOVA) analysis determined significant difference among the three teaching methods using SPSS 16.0 statistical software, F (2, 36) = 5.40, p = .009. The *F* value obtained indicated that the data supported the alternate hypothesis that there was a statistically significant difference in lab activity scores of students in Group 3 who were taught using didactic-based instruction, inquiry-based instruction, and the combination of two approaches.

Table 10

Group 3 Analysis of variance (ANOVA) Results

Group 3 ANOVA Results					
	Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Between Groups	401.44	2	200.72	5.40	.009
Within Groups	1338.92	36	37.19		
Total	1740.40	38			

For Group 3, Table 11 represents additional data analyses using the Tukey Honestly Significant Difference (HSD) Post Hoc. Each of the rows represents a comparison of two groups. The first row compares the means for Group 1 and Group 2 (3.54. or- 3.54) along with a standard error, *p*-value (―Sig.) .313, SE = 2.39, and a confidence interval. For the second row, the comparison of the means for Group 2 and Group 3, (-4.31 or 4.31) along with a standard error, p value (―Sig.) .184. For the third row, the comparison of the means for Group 3 and Group 1, (-7.85 or 7.85) along with a standard error, *p* value (―Sig.) .006 (Kirkpatrick & Feeney, 2009). The Tukey HSD comparisons of the three teaching methods revealed that there was statistically significant difference between the didactic and the combination of two approaches, F(2,36) = 5.40, p = .006. There was no statistically significant difference between the combination of two approaches and inquiry instructional methods, F(2,36) = 5.40, p = .184. No statistically significant difference was found between didactic and inquiry instructional methods, F(2,36) = 5.40, p = .313.

Table 11 *Group 3 Tukey Honestly Significant Difference* **(***HSD) Post Hoc Comparison of Teaching Methods*

Descriptives for Group 3

(I) Teaching Method	(J) Teaching Method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1	2	-3.54	2.39	.313	-9.39	2.31
	3	-7.85*	2.39	.006	-13.69	-2.00
2	1	3.54	2.39	.313	-2.31	9.39
	3	-4.31*	2.39	.184	-10.15	1.54
3	1	7.85*	2.39	.006	2.00	13.69
	2	4.31*	2.39	.184	1.54	10.15

*The mean difference is significant at the 0.05 level.

For Group 3, Table 12 identifies the homogenous subsets of means—set of means that do not differ significantly from each other. The left column lists the means for the groups from smallest (Group 1) to the largest mean (Group 3). The two columns to the right list the actual means in subsets. The first subsets contain Groups 1 (mean = 84.00) and 2 (mean = 87.54), while the second subset contains Groups 3 (mean = 91.85). This indicates that for Groups 1 and 2, the means were not significantly different. However, Group 3 was in a different subset and its mean differed significantly from the means of the groups in subset 1 (Kirkpatrick & Feeney, 2009). The eta-squared calculation η^2= SS between/ SS total = % = 462.97/1792.46 = .26. Therefore, $F(2, 36) = 3.26$, $p< .05$, $\eta^2 = .26$.

Table 12 *Group 3 Tukey Honestly Significant Difference (HSD) Means of Teaching Methods*

Teaching Method	N	Subset for alpha = 0. 05 1	2
2	13	84.00	
1	13	87.54	87.54
3	13		91.85
Sig.		.313	.184

Means for groups in homogeneous subsets are displayed.

Based on the data analyses, the null hypothesis was rejected as well. There was a statistically significant difference in lab activity scores of the students in Group 3 who were taught using didactic- based instruction, inquiry-based instruction, and the combination of two approaches. This indicated that the means for didactic and inquiry teaching methods were not statistically different **= .**05, but each was significantly different from the means for the combination of two approaches.

4. Discussion

4.1 *Hypothesis Analysis*

The hypothesis of the research study was analyzed for the biology classes using single-factor, independent-measures analysis of variance (ANOVA) to compare the three instructional methods to students' scores on standardized laboratory activities. The ANOVAs, Group 1, F (2, 36) = 4.20, p = .023 (Table 2), Group 2, F (2, 36) = 4.65, p = .016 (Table 6), and Group 3, F (2, 36) =5.40, p = .009 (Table 10), indicated that there were statistically significant differences in student scores on the standardized laboratory activities among the three instructional methods—didactic (teacher-directed), inquiry-based and the combination of two approaches. Because there were statistically significant results from the data analyses, the investigator of this study conducted further analyses through the Tukey Honestly Significant Difference (HSD) Post Hoc Comparison of Teaching Methods. The analyses showed that for Group 1, $F(2, 36) = 3.26$, $p<.05$, $\eta 2= .19$ (Table 3), Group 2, $F(2, 36) = 3.26$, $p<.05$, $\eta 2= .26$ (Table 7), and Group 3, $F(2, 36) = 3.26$, $p<.05$, $\eta 2= .23$ (Table 11), there were differing results among the three teaching methods. The analyses identified greater and statistically significant difference between combination of two approaches and didactic instructional method.

However, except for the students' scores in Group 2, there was no statistically significant impact on the scores of students in the three groups between didactic and inquiry instructional methods, nor the combination of two approaches and inquiry instructional methods. Finally, the eta-squared ($\eta 2$), Group 1, .19 (Table 4), Group 2, .26 (Table 8), and Group 3, .23 (Table 12), provided proportional measures between the factor variability to the total variability (Tables 4, 8, and 12). Those results indicated that the eta-squared ($\eta 2$), of the scores from students' responses to laboratory activities administered to all three classes were explained by the type of instruction with three levels—didactic method, inquiry method, and the combination of two approaches of instruction. The remaining percentages might be explained by other variables not under investigation in the research study. The findings of the data analyses from the research study allowed the investigator of this study to arrive at conclusions that will be discussed in the interpretation of the findings.

4.2 Interpretation of Findings

The research study attempted to determine if there was a statistically significant difference in students' scores on standardized laboratory examinations when teachers used didactic, inquiry, and the combination of two approaches. The research problem focused on the most effective method that would positively affect standardized laboratory performance, and retention of biological concepts.

After reviewing the literature regarding how children learn information, the investigator of this study formulated the research study through the constructivist theory. Piaget (1973) conceived the definition of constructivism, and Bruner (1975) extended the concept of the constructivist theory of learning (Lambert, Walker, Zimmerman, Cooper, Lambert, Gardner & Szabo, 2002). That theory indicated that each learner created knowledge over time because of the interactions with the environment. In addition, inquiry and didactic methods of teaching influence the way children learn science concepts because compared to didactic methods, the inquiry process involves the active and comprehensive nature of constructivism.

The investigator of this study developed the hypothesis of this research study to investigate: the continuing controversy surrounding the claim of those researchers regarding how students acquire science concepts (Bybee & Van Scotter, 2006; Campbell, 2006; Leshner & Perkins-Bough, 2006; Lord & Orkwiszewski, 2006; Olson & Lang, 2004; Manlove et al., 2006; Wee et al., 2007; Wenglinsky & Silverstein, 2006; Wood, 2005). The suggestions of other researchers who asserted that educators might face challenges with the use of the inquiry process because of resistant to the process from the learners and the teachers (Regassa & Morrison-Shetlar, 2007).

At the same time, other researchers suggested that didactic method of instruction with some degree of modification might be an effective method of instruction (Bland et al., 2007; Estes & Dettloff, 2008). Therefore, the investigator of this study wanted to discover if a combination of the optimal principles from didactic and inquiry teaching methods would enhance students' performance and acquisition of knowledge in biological laboratory investigations. The findings related to the research question will be discussed, and the investigator of this study will arrive at a conclusion regarding the most effective instructional method—didactic-based instruction, inquiry-based instruction, or the combination of both approaches to support the hypotheses of this research study.

Based on the findings, the instructional approach influenced students' scores on standardized laboratory examinations due to the statistically significant F values for all three groups of students as reported in section four:

- The analyses of variances (ANOVAs), Group 1, F (2, 36) = 4.20 p = .023 (Table 2), Group 2, F (2, 36) = 4.65, p = .016 (Table 6), and Group 3, F (2, 36) =5.40, p = .009 (Table 10), provided the evidence needed to support the alternate hypothesis. The hypothesis stated that there was a statistically significant difference in lab activity scores of three high school biology classes taught using didactic-based instruction, inquiry-based instruction, and the combination of two approaches. In addition, the findings revealed greater and statistically significant difference in scores between the combination of two approaches and didactic instructional methods for all three classes.
- The findings supported the assertions that the investigator of this study discovered in the literature review regarding didactic teaching. Skoumios and Hatzinikita (2008) proposed that students would not display the ability to improve their critical thinking skills or explain the reasoning behind the answers to questions to complete the standardized laboratory examinations if didactic instruction was the method used. In addition, when teachers engaged in didactic instruction, there was no opportunity for active learning from the students (Lord & Orkwiszewski, 2006). However, as Jones (2007) proposed, if teachers combined techniques from the didactic process with technological resources, then some students might realize success in improving scores in laboratory assessment. This coupling would be equivalent to the combination of two approaches that incorporated techniques from both inquiry and didactic instructional methods. In contrast, the literature review proposed that inquiry was the best instructional method for helping students to understand scientific concepts in all areas of science (Bybee & Van Scotter, 2006; Lord & Orkwiszewski, 2006). Therefore, this research study attempted to develop a better understanding of the support for inquiry instructional methods as a more positive contributing factor in students' retention of scientific concepts (Campbell, 2006). While inquiry method might indeed create the optimal learning environment and sustainable knowledge for the student, the teacher still has to prepare the student via didactic learning to ensure that students understand and can participate in inquiry-based learning (Regassa & Morrison-Shetlar, 2007). In addition, while the literature review suggested that inquiry instructional method would certainly be the method of choice in helping students gain better understanding of the material (Bybee & Van Scotter, 2006; Lord & Orkwiszewski, 2006), according to the findings from this study, some didactic instruction was necessary.
- The findings of the study indicated that there was a significant difference in student scores on standardized laboratory activity examinations among didactic, inquiry, and the combination of two approaches of instruction. Further, the investigator of this study concluded from the findings that there was a higher level of student achievement with the use of the combination of two approaches. Consequently, the investigator of this study recommends that science teachers begin to incorporate the didactic and inquiry methods of instruction into both laboratory activities and classroom discussions for biology and other science courses.
- As science administrators and educators continue the country-wide discussions on how to bring our students to the forefront in science education, the investigator of this study recommend further research in the area of science instructional methods. The research study, and the quantitative approach used, may be implemented through a year-long study with larger student samples. With larger samples, the *F* values would be statistically reinforced. In addition, the research study could be conducted in other grade levels where students are investigating science concepts in chemistry, physics, ecology, and the advanced science subjects.
- In addition, because the data used in this research study data were from the scores of female students, the same study could be implemented at other all-girls' institutions. In addition, similar studies might be undertaken at various all-male institutions as well as at co-educational institutions to discover the consistencies or inconsistencies of the findings in this research study. The completion of such research studies will ensure that science instructional methods continue to be the focus of continued development to ensure that students have all the opportunities needed to succeed in science.

- Further, instead of using a quantitative approach, future research could investigate the optimal teaching method using a qualitative method. While several research questions would be possible, one research question could investigate the perceptions of biology teachers, practicing inquiry-based teaching, on the College Board examination assessment. The volume of information that student should know before completing the standardized examinations, is often difficult to accomplish using inquiry- based instruction. The investigation might be completed through face-to-face interviews, and participant observations. The findings would help educators better understand the reasons for teacher‘s reservations with teaching the content to advanced biology students.
- While the literature review provided positive support for inquiry as the optimal method of instruction, the data analysis of section 4 did not support that conclusion. Therefore, future research could investigate: a) whether the inquiry method of instruction results in greater retained knowledge or better learning in biology classes, or b) if the didactic method results in greater retained knowledge or better learning in biology classes.

5. Conclusion

The rapid advances in technology require that the United States of America find ways to regain prowess in the field of science. As the country continues to focus on recapturing its position in science globally, the science educators have to incorporate new ways of reaching students so that they regain their former level of distinction. Our country‘s progress and the future of science depend on educated science students who can capitalize on the global opportunities. The modern science classrooms are reflections of the ethnic, racial, social, and economic diversity of the world (Arreguin-Anderson & Esquierdo, 2011; Bybee & Van Scotter, 2006), and science educators must rise to the challenges of developing new instructional methods to meet the needs of the students who have varying abilities depending on their backgrounds. The research study investigated if there was a relationship between type of instruction and the levels of student learning achievement in high school biology classes for each instructional method.

- The didactic instructional method does allow for clarification of certain concepts that students might be seeing but do not understand and so they find it difficult to diagnose the reason laboratory activities do not go as planned. The findings of this research study that support the use of the combination of two approaches should be considered when science administrators are developing techniques to help students learn during the laboratory sections of the biology curriculum.
- The findings support the hypothesis that a combination of two approaches will produce improvement in student achievement in biology. The greatest challenges for the educator who wants to use a combination of two approaches of instruction is that the teacher has to develop a clear understanding of didactic and inquiry teaching methods. The teacher must then gain some experience in the use of the two methods before undertaking the use of the combination of two approaches. However, success in science teaching and learning can be assured as administrators and educators continue further research. They are encouraged to use the findings such as those of this study to promote reform discussions for the science classrooms.
- Science administrators and teachers could use this research study to begin reform and paradigm shift in the science curricular initiatives and to advance professional development in biology laboratories with the possibility of further application at the local level and the wider educational setting.
- The discoveries of this research study could help other members of the educational community to begin discussions on optimal teaching methods in other science and curricular areas. Teachers would become aware of the efficacy of each instructional method as they engage in professional development initiatives surrounding science instructional methods, and the methods used in other subject areas. The initiative could be the core of future research to support instructional processes in science and all other subject areas.

- Further, instead of using a quantitative approach, future research could investigate the optimal teaching method using a qualitative method. While several research questions would be possible, one research question could investigate the perceptions of biology teachers, practicing inquiry-based teaching, on the College Board examination assessment. The volume of information that student should know before completing the standardized examinations, is often difficult to accomplish using inquiry- based instruction. The investigation might be completed through face-to-face interviews, and participant observations. The findings would help educators better understand the reasons for teacher‘s reservations with teaching the content to advanced biology students.

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