The Effects of Inquiry-Based Instruction on Student Achievement in Science

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ABSTRACT

More than half of the student population is labeled with educational learning disabilities, therefore, a variety of different learning styles exist in the classroom. With these different learning styles, the call and response teaching method is losing the attention and interest of the students. As a result of the lack of interest, the failure rate increases. Having more inquiry based learning incorporated in the classroom would reach most learning styles, keep the interest and produce a greater success rate.

CHAPTER I

INTRODUCTION

Between 1958 and 2012 there has been a long series of exhortations to restore America's school system to a leading position in the world. The concerns about the quality of U.S. schools intensified in 1983, when a government task force submitted to the Ronald Reagan administration a widely heralded report carrying the title "A Nation at Risk" (Chandler, 2012). In 1989, with the calls for improvement continuing, President Bush, together with the governors of all 50 states, set goals that would bring U.S. education to the top of the world rankings by the year 2000. In President Clinton's first year in office, in 1993, he encouraged the passage of the Goals 2000: Educate America Act "so that all Americans can reach internationally competitive standards" (p.13). Two years later the legislation was enacted into law by a wide, bipartisan congressional majority. When announcing his competitiveness initiative in 2006, President Bush observed that "the bedrock of America's competitiveness is a well-educated and skilled workforce" (NCLB, 2002).

Teaching and learning science ought to be contained elements of action and change. Learning is not just an academic task, but it is about interacting. Science teaching and learning should include the content, process, histories, norms for participation, and discursive practices. Students should be viewed as producers and users of science. Science is a social activity and involves understanding how human values and characteristics shape scientific knowledge. A lot of time students find the subject science as being a very difficult subject to learn because of the theories and processes. Therefore, students' achievement in science has been low. Using the right instructional strategies and programs can make the learning process an exciting time of discovery, empowering students to be scientifically literate citizens. (Cobern, Schuster, Adams,

Applegate, Skjold, & Undreiu, 2010).

During the 2011 academic year, educators developed an understanding of the new Maryland Common Core State Curriculum Standards and Frameworks and how science (STEM) education aligns with the new curriculum. The Common Core State Standards provide a consistent, clear understanding of what students are expected to learn, so educators and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that young people need for success in college and careers (MSDE, 2012).

Inquiry-based learning is defined as involvement that leads to understanding; possessing skills and attitudes that permit students to seek resolutions to questions and issues while the constructing new knowledge.

Direct learning models are based on repetition, memorization, and demonstration of actual skill sets in order to impart information to a student. Engaging students is a great priority in order to create their success (Forbes & Zint, 2011).

Statement of Problem

Students learn better from direct instruction methods or inquiry-based instruction as opposed to traditional instruction.

Hypothesis

The null hypothesis for this study was there would be no difference in achievement between those students who received inquiry-based instruction compared to those students who received direct instruction.

Operational Definitions

The dependent variable in this research was student achievement, which was measured by a Short Cycle comprehensive assessment created by a select group of science teachers employed with Baltimore County Public School.

The independent variable was the teaching methods, which was operationalized using direct instruction verses inquiry-based instruction.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review discusses the achievement of middle school students in their science classes. The first section explores the background of traditional schooling. The second section discusses the challenges educators are faced with of traditional schooling. Section three discusses new teaching strategies; direct instruction, explicit instruction, and inquiry-based instruction. The final section, discusses the benefits of inquiry based learning.

Traditional Schooling

Teachers stand in front of the class and teach. Students sit in rows and are polite. Schools don't have to deal with complex social issues. Students sit at their desks, listening to lectures, memorizing facts to prepare for a test. This is a picture of what is considered traditional schooling. Such schooling may not be sufficient to prepare kids with the skills needed to compete in today's world. Traditional education or back-to-basics refers to long-established customs found in schools that society has traditionally deemed appropriate (Robelen, Kelley, Madden, Gardner, & Rudman, 2011). Some forms of education reform promote the adoption of progressive education practices, a more holistic approach that focuses on individual students' needs and self-expression. In the eyes of reformers, traditional teacher-centered methods focused on rote learning and memorization must be abandoned in favor of student-centered and task-based approaches to learning. However, many parents and conservative citizens are concerned with the maintenance of objective educational standards based on testing, which favors a more traditional approach (Barton & Fusco, 2001).

Challenges of Traditional Schooling

It is based on old learning theories: that we must learn simple tasks before complex ones, and that only measurable learning is worthwhile. Students do not have a sense of the overall purpose of the simple steps. However, if students are told the purpose, by using advance organizers, this disadvantage is overcome. Teachers cannot assess what the students' prior knowledge is, so the teacher will be unaware of why particular students cannot learn (Beach, 2012). Retention of how to solve the problems is low, because the students have not struggled with the problem themselves. This disadvantage can be overcome by having the students do many complex problems on their own. Direct instruction as an instructional method works for only a small percentage of students, not for a great variety. The students who have other than verbal "intelligence", or who come from different cultural world views will fail (Mangu-Ward, 2010).

Different Teaching Strategies

Different instructional strategies determine the approach a teacher may take to achieve learning objectives. Instructional methods are used by teachers to create learning environments and to specify the nature of the activity in which the teacher and learner will be involved during the lesson. While particular methods are often associated with certain strategies, some methods may be found within a variety of strategies (Adams & Carnine, 2003).

Direct Instruction

Direct learning models are based on repetition, memorization, and demonstration of actual skill sets in order to impart information to a student (Adams & Carnine, 2003). Direct learning methodology demands a very specific lesson plan in which almost every moment of classroom time is utilized with a preplanned activity or mode of instruction. In comparison, inquiry based learning encourages personal discovery on the part of the learner and the lesson

plans may be less structured. Direct learning is often criticized because of its emphasis on rote memorization, whereas discovery learning depends more on critical information gathering on the part of the student in order to fully understand the concepts behind the material that is being presented. Discovery learning stresses the importance of the student mastering the lesson thru exploration, questioning and experimentation on his or her own rather than being directed by a teacher in a specific series of instructions. It can be argued that while direct learning methods may do an excellent job in "drilling" a particular series of facts into the learner, the discovery model will encourage the student to more fully explore the curriculum and truly understand the underlying principles. Direct instruction strategy is highly teacher-directed and is among the most commonly used (Moore, 2012).

Explicit Instruction

Explicit teaching involves directing student attention toward specific learning in a highly structured environment. It is teaching that is focused on producing specific learning outcomes. Explicit teaching is useful for introducing topics and specific skills. Topics and contents are broken down into small parts and taught individually (Hall, 2009). It involves explanation, demonstration and practice. Students are provided with guidance and structured frameworks. Topics are taught in a logical order and directed by the teacher. A characteristic of explicit teaching involves modeling skills, behaviors and thinking. This involves the teacher thinking out loud when working through problems and demonstrating processes for students. The attention of students is important as well as listening and observing.

Inquiry-Based Instruction

Inquiry-based learning was first developed during the discovery learning movement of the 1960's. It was developed specifically to address or correct a perceived flaw in the contemporary

strategies for learning that were then being employed; namely that students were being forced to memorize huge quantities of material without having a more active role in the actual development of skills related to the subjects they were studying (Yager & Akcay, 2010). This method stresses the importance of developing skill sets over retaining specific knowledge. In applying inquiry-based learning to science, the idea of "open learning" becomes very important. In a more traditional method of scientific education, if students are working on an experiment for example, they are told what the results of the experiment will be in advance, or what the results are anticipated to be, and the students' role in the process is simply to confirm these results (Gyllenpalm, Wickman, & Holmgren, 2010). With inquiry-based learning, the students will be encouraged to discover what the result of the experiment is for them. This encourages them to take a more active role in understanding not only the methods and principles surrounding the experiment, but also in evaluating the strengths and weaknesses of their own results as they search for solutions (Latta, Buck, Leslie-Pelecky, & Carpenter, 2007).

Within the field of modern education, collaborative inquiry learning is making its mark as a new and expansive method through which students can enhance their education and incorporate aspects of the scientific method within their learning strategy (Barry, Blumenfeld, Fishman, Marx, & Soloway, 2000). Research is showing the benefit of this educational strategy with a wide spectrum of students, including assisting those with "severe and profound" learning difficulties. In order to determine the effectiveness of inquiry learning versus other methods in the classroom setting, numerous studies have been undertaken which demonstrate that inquiry-based learning does "hold its own" when put to the test. To completely understand how collaborative inquiry learning is employed within a classroom, it is important to research how

this particular method was developed and the history behind its usage (Baker, Barstack, Clark, Hull, Goodman, & Kook, 2008).

Orienting and asking questions are considered the beginning of an inquiry. Students are encouraged to view scientific data or phenomena that spark their curiosity and encourage them to ask questions (Tan & Seah, 2011). As a student's knowledge of the scientific method increases, he or she would be encouraged to ask "better" questions, i.e. questions more suited to the creation of hypotheses as the students' confidence in their own scientific ability increases. This leads into the second category, namely the generation of a hypothesis. It has long been considered a problem within the field of science that many students do not know how to create a proper hypothesis. That is why, as was stated previously, guiding the student to ask specific questions during the initial inquiry process can assist in laying the groundwork for a proper hypothesis that contains an "if-then" statement (Baker, et al, 2008).

Benefits of Using Inquiry-based Learning

Communication is a step that requires the student to present or report their results in a coherent and effective manner. It helps the student to become a better organizer as he or she must now put together the results of their experimentation and make claims that are supported by the data they have generated (Sinnema, Sewell, & Milligan, 2011).

The entire inquiry process is meant to foster a greater understanding of the scientific method within the student so that they can eventually work more independently to develop coherent hypotheses and experimental models (Yager & Akcay, 2010).

In order for inquiry based learning to be successful, especially within the field of science, it is important that a student be encouraged to develop a strong set of skills that will help him or her be able to ask effective questions, formulate hypotheses using if-then statements, properly

utilize tools to collect data, and create efficient models that reflect the specific data collected. The student should become more advanced in the process of scientific inquiry with each foray into experimentation. Because inquiry-based learning is grounded in constructivism, namely the theory that that human generate knowledge and meaning from an interaction between their experiences and their ideas, it is crucial that the importance of both elements are stressed (the experiences, or data, and the ideas, or hypotheses) (Yager, & Akcay, 2010). Both of these elements are crucial to the scientific process, and understanding not only how to properly formulate hypotheses, but also employing the proper methods in testing them and clearly understanding the data that arises from experimentation and how to interpret said data is extremely important (Yager, & Akcay, 2010).

Summary

Throughout the years there have been many changes in the educational process for both teachers and students alike. In modern classrooms there has been a move away from simple rote memorization with a new emphasis on developing sets of skills that will allow the student to work more independently and gain a broader understanding of the curriculum that they are expected to learn. Specifically in the realm of science, inquiry-based learning has been highly encouraged as it pushes students to carefully observe the scientific phenomena around them and develop their own hypotheses regarding what they see, which is the beginning of the scientific method (Daley, 2011). By encouraging students to follow the nine steps and providing them with the proper tools to effectively collect data and construct models, while at the same time asking them to form their own theories and draw their own conclusions, the hope is that will create better scientists in the future. By familiarizing students early-on with the components of the scientific method and encouraging them to explore the world around them with inquiry-based

learning, this allows the student to gain a clearer understanding of what is required to truly master the realm of science and make new and exciting discoveries.

CHAPTER III
METHODS

Design

This study used a quasi-experimental design focusing on one group of students. This group consists of both special and regular education students. The dependent variable in this research was students' achievement. Students' achievement was measured by Baltimore County Public Schools Science Short Cycle Assessments. The independent variable was the teaching method (direct instruction verse inquiry-based). The direct instruction method was presented for two weeks and the inquiry-based method was also present for two weeks.

Participants

For this study, there were 27 eighth grade participants from a Baltimore County Public School. Of those 27 students, 15 were females and 12 were males. In this class, there were 24 regular education students, two students were English as a Second Language (ESL), and three students were on a Plan for Students Identified with a Disability (504). All participants ranged in age from 13 to 15 years old. The participants consisted of 14 African American, 10 Caucasian, and 3 from other racial and ethnic groups.

Instrument

The researcher used the Baltimore County Public School Science Short Cycle Assessments to measure the students' achievement science (chemistry) content. These assessments were developed by the school system's science department. The developers of this test consisted of a team of educators from both inside and outside of the classroom. The summative assessment includes selected responses and brief constructed responses. The Short Cycle Assessment was tested for both reliability and validity. This assessment was tested and reviewed by Baltimore County Public School Science Department. Each section of this Science

assessment was given to a particular group of students at selected schools across the county to test the reliability and validity. This assessment was given after the students were taught particular topics to verify and measure the knowledge and comprehension gained. This assessment consists of 13 selected response questions and 1 brief constructed response (BCR).

Procedure

Participants involved in this study received two types of instructions, direct instruction and inquiry-based instruction. All participants met five days a week for 50 minutes during 10:50 A.M. - 11:40 A.M.

As the students arrived to science class, they retrieved their needed supplies for the lesson. The students placed their homework in their designated space in the classroom. This overall daily routine was done with minimum to no directions from the educator. The students participated in the daily warm-up (five minutes) activity. Once the warm-up was discussed, the students were given a PowerPoint presentation as an introduction with the objective, and vocabulary word(s) for the lesson. This lesson starter was used during both types of instruction.

Inquiry-Based Instruction

The introduction of the lesson always began with a brief discussion/demonstration (two minutes) about the students' prior knowledge of the topic, engagement. The students' then participated in hands on activities/investigations with guidance in order to explore the topic of the science lesson. The next day, the students learned new concepts and skills to clarify what they explored the day before. They used graphs, charts, and concept maps to help explain their understanding of concepts and processes. The students were allowed to elaborate through different activities to apply their knowledge of the content and skill. An evaluation "analysis" was given at the end of each lesson to assess their knowledge, skills and abilities from the lesson

that was taught. The participants used their Interactive Notebook (INB) for this particular instruction. Interactive notebooks enable students to be creative, independent thinkers and writers.

Direct Instruction

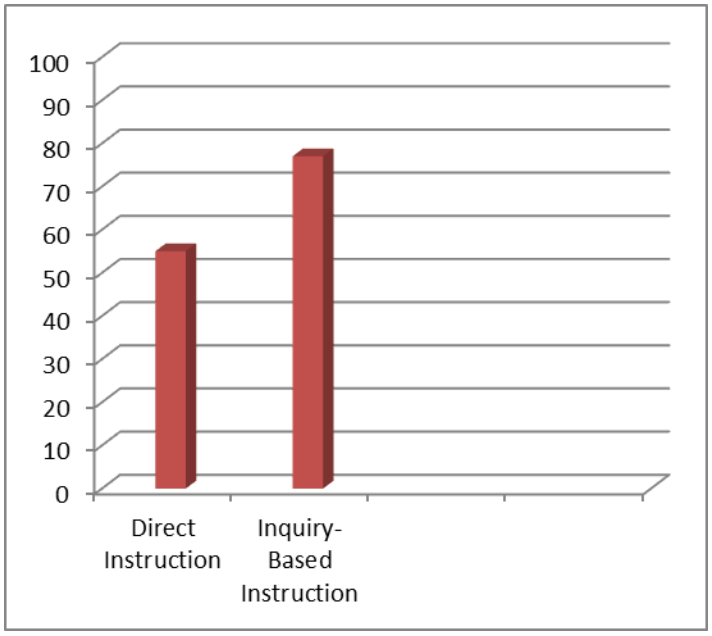
In contrast, the researcher started each lesson by activating the students' prior knowledge by showing real-life examples of the science topic, using mini science experiments, scientific props, discussing relevant characteristics, or watching a movie clip, directly related to your lesson plan's stated objective. The students would read a text on the relative topic. They took notes using graphic organizers or concept maps. The participants would answer questions in order to identify how well they understood the information they were presented.

CHAPTER IV

RESULTS

The analysis revealed a significant difference between the mean score of direct instruction and inquiry-based instruction, t (25) = -5.83, $p < .05$. The mean score for direct instruction is 55%, while inquiry based instruction has a mean score of 78 %.

Figure 1: *Mean scores on from Direct Instruction) and 2 (Inquiry-Based Instruction)*



The results were analyzed to determine the impact of race on performance well. For the African American students there is a significant difference between direct and inquiry-based instruction (t (11) = -4.239, $p < .05$). Inquiry-based shows a higher mean score. African American students had more success with inquiry-based instruction by more than 20%. For the Caucasian students there is a significant difference between direct and inquiry-based instruction t (9) = -2.786, $p < .05$. Caucasian students had more success with inquiry-based instruction by 25%. For the students of other race and ethnicity there is a significant difference between direct

and inquiry-based instruction. t (3) = -2.933, p < .05 (Figure 2). The students from other races also had more success with inquiry-based instruction by 25%.

Figure 2: *Mean scores by Race for Direct Instruction and Inquiry-Based Instruction*

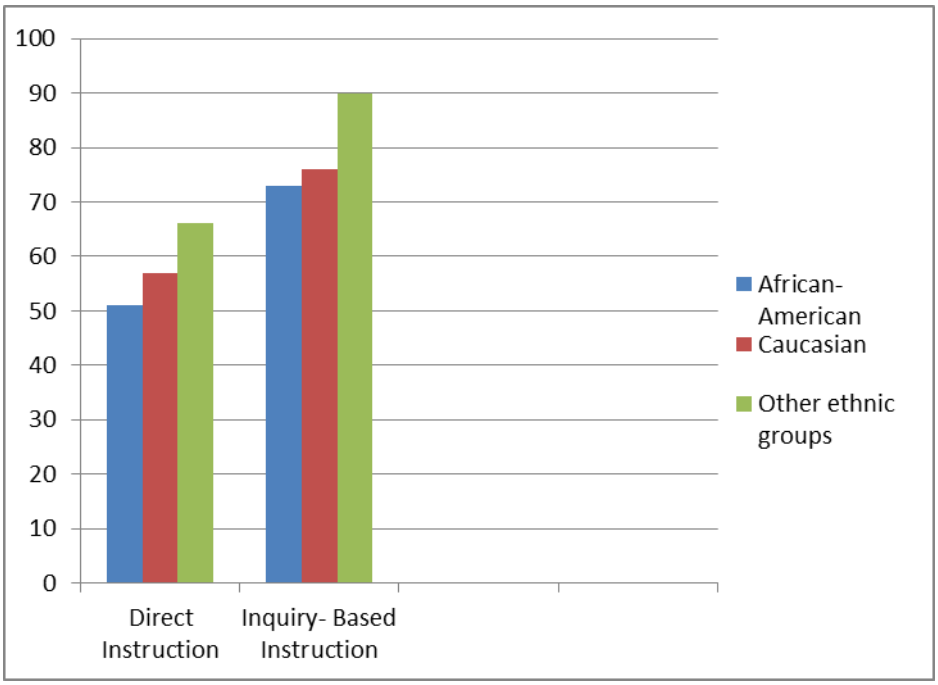
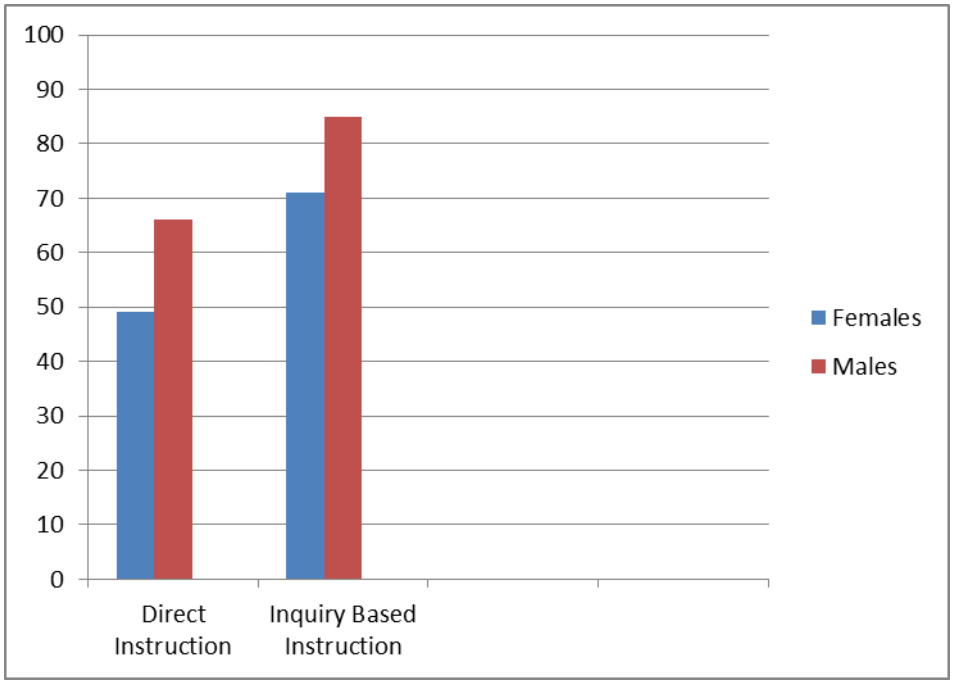


Figure 3: *Mean scores by Gender Direct Instruction and Inquiry-Based Instruction*



Gender was also analyzed, and significant differences between the mean score in each group were evident. The female students' mean score showed significantly higher scores on inquiry- based instruction (M = 72%) than on direct instruction M = 48% t (15) = -4.813, p < .05. The male students' mean score showed significantly higher scores on inquiry-based instruction than on direct instruction increased as well t (9) = -3.174, p < .05.

The hypothesis for this study states that there would be no difference in achievement between those students who receive inquiry based instruction compared to those students who receive direct instruction. The results of this study confirmed this hypothesis was rejected.

CHAPTER V

DISCUSSION

The purpose of this study is to determine whether or not the implementation of inquiry based lessons will improve middle school students' achievement in their science classes.

The null hypothesis for this study states that there would be no difference in achievement between those students who receive inquiry based instruction compared to those students who receive direct instruction. As a result the null hypothesis can be rejected.

Discussion of Results

The mean score from direct instruction and inquiry-based instruction shows a significant difference. The researcher analyzed data in different categories, by the overall population, race and gender. The students' involved in this study showed a significant difference of achievement between inquiry–based instructions and direct instruction. The students performed better on the assessment that followed inquiry-based instruction.

As stated previously, traditional schooling is not reaching our current student population. With this current problem, educators must implement a new method of teaching to reach our students. It is imperative to increase student achievement. Direct learning methodology demands a very specific lesson plan in which almost every moment of classroom time is utilized with a preplanned activity or mode of instruction. In comparison, inquiry-based learning encourages personal discovery on the part of the learner and the lesson plans may be less structured.

Other theories showed a significant increase in student achievement in science as well. However, there is still a small student population who achieves better with direct instruction.

Threats to Validity

For this study, there are two major threats to validity: differential selection and external generalization. Differential selection was a threat to validity because the participants were not randomly selected for this study. External generalization was a threat to validity because the researcher used the same students at the same time in the same place.

Comparisons to Previous Research

It has been confirmed that student achievement has decreased across the curriculum. However, educators must enforce a method to reduce this achievement gap. In science, students would benefit from inquiry-based learning because it offers development of habits of mind that can last a lifetime and guide learning and creative thinking. This study reinforces that student achievement would be better in their science class if educators would implement inquiry-based instruction instead of direct instruction. Within a conceptual framework, inquiry learning and active learner involvement can lead to important outcomes in the classroom. Students who actively make observations, collect, analyze, and synthesize information, and draw conclusions are developing useful problem-solving skills. These skills can be applied to future "need to know" situations that students will encounter both at school and at work.

Other researchers such as Costa and Suchman (2004) believed that the inquiry-based instruction approach help students to better grasp the knowledge of, become more [inquisitive], and transfer the knowledge. They continue thinking about it longer than traditionally-based instruction or traditionally-based approaches. It has been compared and researched numerous times throughout the years. The earliest example of research was between 1903 or 1906. Students were taught how to spear fish in a tank. After the students learned how to spear the fish, they put them to work. In the other group, the students experimented for themselves. They

participants found a relationship and constructed the relationship about the refraction of light and where you had to aim to spear the fish. That gave the students the opportunity to apply that knowledge. And the ones who constructed their own meaning did a better job spearing the fish than did the kids who were taught directly.

Implications for Future Research

In this study the increases of students' achievement were to be implemented again, the researcher should decrease the threats to validity by analyzing and comparing the quantitative data. Quantitative data is measurable data. An increase of participants is necessary in order to produce accuracy of the mean score.

In conclusion, it is highly required for educators to fully prepare our American students for the future. Building on the excellent foundation of standards states have laid in providing our young people with a high-quality education. Educators must explore opportunities for the 21st Century with the focus on problem-based learning.

Inquiry implies involvement that leads to understanding. Furthermore, involvement in learning implies possessing skills and attitudes that permit students to seek resolutions to questions and issues while constructing new knowledge.

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