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The Effect of Project-Based Learning on Student Mastery of NGSS Practices

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The Effect of Project-Based Learning (PBL) on Student Mastery of NGSS Practices

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Abstract

Project-based learning diverges from traditional learning methods of the past by engaging students in the application of curriculum through the creation of products that represent their understanding of important skills and concepts. This research compared the rigor of project-based learning tasks with traditional learning tasks, and examined achievement differences between students taught with project-based learning and traditional instruction. To do so, a group of 81 students participated in a study in which the performance of a control group participating in traditional learning methods was compared to that of students who participated in project-based learning tasks. It was found that on an end-of-unit assessment, the project-based learning group outperformed the control group. This suggests that, compared to traditional learning methods, more rigorous project-based learning methods increase student understanding of the curricular skills and concepts.

Introduction

The way that science is taught in today's classrooms has dramatically changed in recent years with the emergence of new teaching and learning practices that incorporate the Next Generation Science Standards (NGSS) and 21st Century Skills. Prior to 2013, science education was in flux and not grounded in the most current research on science practices (NGSS Lead States, 2013). This adaptation of the Next Generation Science Standards requires teachers to use different strategies than traditional lecture. These new and innovative standards require new and innovative teaching methods that develop science and engineering practices by asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and finally obtaining, evaluating, and communicating information (NGSS Lead States, 2013). Additionally, 21st Century Skills require students to think critically, be creative, collaborate, and communicate as they apply literacy and leadership concepts towards classroom content. One teaching practice that marries these ideas together is project-based learning. Project-based learning affords students the opportunity to immerse themselves in interesting and relevant content in a meaningful way. This allows them to develop their scientific and engineering practices or 21st Century Skills in a manner that traditional teaching methods cannot.

The purpose of this action research was to examine the effect of project-based learning on student mastery of standards for the NGSS scientific and engineering practices within a high school science class. In this study, students participated in project-based learning tasks involving content-specific standards along with NGSS practices. The outcomes of the experimental group participating in project-based learning tasks was compared to a control group that participated in traditional learning tasks. Addressed in the study were the research questions: are project-based learning tasks more rigorous than traditional learning tasks, and will project-based learning improve student scores on an end of unit assessment? Results were analyzed and communicated based on the caliber of rigor for the activities completed within the learning segment and the differences in post-assessment scores between the experimental and control groups.

Since the time of the Space Race, our civilization has been dependent upon innovative minds to further science, technology, and medicine in such a way that improves our quality of life while solving problems of the time (Banko, 2013). Project-based learning in the classroom aims to create more of these innovative minds that will shape the future in a positive way. The findings from this action research will inform the teacher researcher’s use of project-based learning in high school science courses.

Literature Review

Introduction

Project-based learning can be defined as a pedagogical practice in which learners acquire new skills or knowledge through problems and challenges that are often tied to real-life engaging experiences. In general, this learning falls under the categories of either an investigation project in which students seek an answer to a question or performance projects in which students are using skills to design solutions to a problem (Kanter, 2010). The following review of literature examines the impact of project-based learning on student achievement, overall perceptions of the project-based learning experience, the effect of project-based learning on rigor, and project-based learning within the field of STEM.

Impact of Project-Based Learning on Student Achievement

Research conducted over the past few decades in the area of project-based learning suggests that a shift towards a project-based learning model in the classroom may have a positive impact on student achievement and experiences across all age ranges, subject areas, and parts of the world. A study of 60 late-elementary aged students from an English classroom in Iran found that students who participated in project-based learning activities significantly outperformed their peers who did not on both a posttest and a delayed posttest (Mohamadi, 2018). According to this study, students retained the information for longer periods of time based on the achievement gap between research groups on the delayed posttest. Similarly, researchers who conducted a case study involving 25 college-level engineering courses in China reported findings in which a 100% passing rate was achieved when using a project-based learning model (Xu & Liu, 2010). Students who participated in project-based learning methods improved on an assessment by an average of 0.34 points per question from the previous years.

When done correctly, project-based learning has the potential to make an impact on the educational performance of minority and female students which may reduce achievement gaps present in classrooms, school, districts, and the country. In general, the population of minority students in the United States are not succeeding at the same rate as the Caucasian population, and the same minority population is also less likely to pursue post-secondary programs in the fields of science and engineering (Kanter & Konstantopolous, 2010). In order to address this issue, one possible modification to traditional classroom instruction is project-based learning. A study of middle-school biology classes with 301 students found that when using project-based learning to teach a unit over the human body and energy transformations, minority student achievement based on pre- and post-test data showed a dramatic increase of nearly 5.5 times the expected growth (Kanter & Konstantopolous, 2010). This finding is important to consider as it not only compares pre- and post-test data, but also compares student growth to the normal conditions as well. It is expected that students would grow from a pre- to a post-test with any type of instruction. However, this study revealed that this growth was more significant under the settings of project-based learning than under more traditional methods of instruction.

One minority population in the field of science that is often overlooked and underrepresented is females. To study the impact that project-based learning may make on this group of students, researchers in Taiwan studied 72 female high-school students as they participated in a STEM competition. Upon the culmination of the competition, it was found that according to analysis of quantitative data and survey results, the female students experienced significantly enhanced student learning, attitudes, and performance as a result of the project-based learning model (Lou, et al., 2014).

The Effect of Project-Based Learning on Rigor

How science curriculum is taught in today's classroom is as important as it has ever been. Research has been conducted to determine how concepts are taught in science classrooms engaged in project-based learning and their impact on student achievement. One such study surveyed 397 teachers across a variety of grade levels to analyze the content and practices within each project-based class. It was found that students in a project-based learning environment engaged in activities ranging from the traditional direct instruction to introduce scientific concepts to the more innovative design or implementation of scientific investigations (Hayes, et al., 2016).

According to a study of 4 public secondary school science teachers who received professional development in the area of project-based learning and then employed PBL in their classrooms, participants' students spent a majority of their time generating and evaluating models rather than recalling information, a more common practice in traditional teaching methods (Khan, 2011). In terms of the level of rigor, the process of generating and evaluating models is one of the higher-order skills outlined within the Next Generation Science Standards and is thus more challenging and impactful to student learning.

In order to identify key characteristics of student success in project-based learning, a study was conducted in which veteran elementary teachers in project-based classrooms in a school of 988 students were observed. It was found that fluency in the standards, integration of student interest, scaffolded instruction, distribution of responsibility, student independence, use of productive feedback, and encouragement of mistakes were a valuable part of the learning process that improved student performance (Mitchell, et al., 2009). As evident in these principles, the primary focus of project-based learning is on the students' learning experience with the teacher acting as a facilitator to guide the students in their learning process. This is done through engaging questions, scaffolded steps, and timely feedback. According to this study, this set of conditions may help students achieve at high levels through project-based learning.

Regardless of the research study parameters and procedures, the strong relationship revealed in the research on project-based learning is that when students engage in meaningful projects in which they are challenged to apply their learning and understanding of concepts or skills in authentic and creative ways, their learning experience is positively impacted.

Perceptions of Project-Based Learning

According to research, the perceptions of classroom climate varied drastically for students using project-based learning compared to those who received traditional instruction. A survey of nearly 500 ninth-grade general science students in Israel found that students who learned via project-based learning were significantly more satisfied, enjoyed the class more, viewed their teacher as more supportive, and perceived teacher-student relationships as being significantly more favorable (Hugerat, 2016). According to this study, project-based learning is viewed positively and improves the academic student experience.

In addition to improved perceptions of the classroom culture, one study suggested that a project-based teaching model may even result in increased student intrinsic motivation. Based on a study of secondary schools in Hong Kong, including 631 students across a range of ages and subjects, it was concluded that when using project based-learning, students perceived more instructional support from their teachers and reported higher intrinsic motivation (Lam, Cheng, & Ma, 2009). When students view the teacher to be motivated and engaged in their projects, their value of the learning process through intrinsic motivation improves as a result.

Inquiry is one form of project-based learning that has been shown to have a positive impact on a student’s perception of the learning experience. A study in Hong Kong examined the effect of cooperative learning through inquiry on a group of 37 sixth-grade female students. In the study each student was assigned a specific role or task around new subject material in which they were expected to investigate in order to find a solution to a problem. Through student surveys, it was found that this form of inquiry was easily accessible, worthwhile, and, most importantly, increased the level of learning and understanding of the topic through interesting and engaging activities (Lau, et al., 2017). In general, this means that students reacted positively to inquiry-based learning in which they were able to dictate their pace, method of delivery, and pathway for learning.

Research conducted across a variety of sample sizes, classroom types, and locations by the Stanford Mobile Inquiry-Based Learning Environment, or SMILE, found that when using inquiry in a science classroom, students and teachers alike were encouraged to be more creative, experiment, and lead to an increase in ownership of the learning taking place (Buckner & Kim, 2014). According to this study, project-based learning or inquiry may hold students and teachers more accountable for the learning within the classroom.

In addition to student perceptions, a teacher’s perceptions, motivation, and attitude also play a role in the potential impact of project-based learning or inquiry on student performance. One study examined a group of 79 future teachers in the fields of math and science who were completing professional development in project-based learning. The goal of the study was to determine whether or not a teacher’s training or perception of project-based learning had an influence on student learning. Two major takeaways were discovered. First, the definition of project-based learning adapted as teachers got further along in the training to incorporate new aspects of instruction. This included a shift from anything involving a project to instruction utilizing inquiry, group work, and extended periods of student-driven learning. Second, it was found that 77% of teachers viewed this definition of project-based learning as beneficial to their students and that this positive viewpoint indicated an increased likelihood to create more authentic implementations (Marshall, et al., 2010). According to this study, adequate training may help teachers accurately define project-based learning in the frame of their classroom, which may improve the implementation.

There is a possible connection between teacher and student motivation when utilizing project-based learning. A study of 631 secondary-aged students in Hong Kong in a variety of subjects yielded findings stating that teachers who identified as having high levels of intrinsic motivation tended to have students who described a feeling of increased instructional support during project-based learning activities (Lam, et al., 2009). According to research, these levels of teacher motivation may be achieved through professional development.

A study conducted by a group from the University of California Berkeley examined how professional development on curriculum projects can improve inquiry-based science teaching. In this study of nearly 800 sixth-grade science students from multiple middle schools, it could be concluded that significant increases in student performance were experienced as teachers were given time and professional development to individualize project-based learning instruction for students (Gerard, Spitulnik, & Linn, 2010). Furthermore, these increases in student performance had a longer-lasting impact as student scores on a delayed post-test were higher for participants than they were for the control group. The overall perception of the learning experience for the experimental group was improved as well, compared to the control group.

Project-Based Learning in STEM

Student perceptions of the classroom environment are able to transcend the walls of the classroom and influence how a student views various subject areas or potential careers and interests. Project-based learning in the fields of science, technology, engineering, or math (STEM) exposes students to new learning opportunities. An international research group in Taiwan found that 30 freshmen engineering students who participated in a project-based learning activity in the area of robotics responded with a positive shift in attitudes towards science, technology, engineering, and math upon the completion of their projects according to questionnaires and interviews (Tseng, et al., 2013). Of those areas, technology was initially the most popular aspect while engineering became the most popular after the learning. This could be explained by the need of students to use engineering skills and practices in a meaningful and authentic manner in order to complete their projects. In traditional teaching methods, in which students do not get the opportunity to apply skills, these practices are not an active part of instruction and thus do not make an impact on making the field of STEM more favorable.

Students at a younger age who have not yet decided on their career paths are also influenced by the exposure to project-based learning activities. A study of 41 seventh-grade students participating in science fair competitions found an increase in the understanding of scientific concepts and positively influenced the attitudes of students towards STEM courses and careers (Schmidt & Kelter, 2017). A survey of students upon the completion of their science fair projects solicited responses that indicated they learned scientific content, how to conduct an experiment, how to collect and analyze data, and how to analyze a hypothesis. These are all critical skills to the application of scientific practices across all fields of science that were both learned and applied through project-based activities in a meaningful way. While some students perceived careers in science to be generally difficult, many students expressed an interest in pursuing future courses and stated an overall positive view on STEM after participating in the science fair.

A successful integration of this new curriculum and project-based learning is best accomplished through the application of real-world examples of the STEM fields in action that allow students to learn the content while applying skills in a meaningful way. Research on STEM reform highlights seven key premises that assist in the effective implementation, which includes a focus on motivation, capacity building with a focus on results, learning in context, changing context, reflective action, tri-level engagement, and persistence or flexibility (Johnson, 2012). The successful implementation of STEM in the project-based learning classroom, according to these principles, is more than just teaching the same curriculum with the addition of a device. Instead, students are challenged to think critically and apply new skills in a meaningful way.

The relationship between project-based learning and technology is an important one as it has the ability to open new doors, expose students to new curriculum, provide creative pathways, and move learning beyond the four walls of the classroom. A study in Taiwan exposed an unspecified number of fifth-grade students to technology in the form of computers and the internet to examine the impact that it may have on project-based learning of science concepts. The study found that students' ability to synthesize and elaborate on new learning improved with the integration of technology through the project-based learning process (ChanLin, 2008). Additionally, technology and project-based learning allowed for the integration of scientific practices that more closely align to standards such as the gaining of necessary knowledge and skills, identifying research tasks, obtaining data and information, organizing and interpreting content, and finally presenting through technological tools.

For American schools, in which technology is already prevalent, there is still a capacity for growth in how technology is used within the classroom. A 2014 study conducted by SMILE across a variety of sample sizes, classroom types, and locations found that through the use of technology, a project-based learning framework is able to trigger a pedagogical shift from the description and recall of information to more rigorous learning that requires the application of skills via problem-solving (Buckner & Kim, 2014). This higher-level learning more closely aligns to today's standards, including those outlined by the Next Generation Science Standards.

Conclusion

Project-based learning has been shown to have a positive impact on student achievement in which students perform better and retain more information over longer periods of time. Additionally, project-based learning enhances the overall student learning experience as students generally describe their perceptions much more positively with teachers making a profound impact on student performance.

Methodology

Research Questions

This investigation of action research uses a mixed methods approach to answer the following research questions: ‘Are project-based learning tasks more rigorous than traditional learning tasks?’ and ‘Will project-based learning improve student scores on an end of unit assessment?’. The main component of the investigation examines the relationship between the method of instruction, traditional versus project-based, and student assessment scores as measured towards mastery of standards. This quantitative data uses pre- and post-assessment score analysis to determine the effect of the change as a result of the instructional method. Additionally, qualitative data is collected to categorize the type of activities throughout the lesson including the level of rigor for each.

Variables

The independent variable in this action research study is the method of instruction. For this variable, students from 2 classes were taught using traditional teaching methods, such as direct instruction and practice opportunities, and 2 classes were taught using project-based methods, such as the independent application of content knowledge for the creation of a finished product.

Setting

This action research took place in a high school Earth Science classroom in a mid-sized city in the Midwest. The research site has a total enrollment of 1,441 students. Demographically, the school population is comprised of 807 Caucasian students, 361 African American students, and the remainder from other racial groups.. In terms of socioeconomic status, 60.24% of the student population qualifies for either free or reduced-priced lunch based on family income. All students in the school have their own personal device provided by the school district as part of a 1:1 program. Earth Science is a required course for ninth-grade students within the school district. Within this study, there were mixed settings in which one section of each research group included a co-teacher to provide special education services.

Participants

A total of 81 students participated in the action research. Of those 81, roughly half, or 42 students were part of the traditional learning group while the other 39 students were part of the project-based learning group. Grade level distribution included: 93% ninth-grade and 7% tenth-grade students. Gender distribution included: 49% male and 51% female students. Race distribution included: 63% white, 31% African American, 6% Hispanic, and <1% other race students. Of the participants, 15% of students received special education services in the form of an individualized education plan (IEP) or 504 plan and 8% did not speak English as their first or primary language.

Collection of Data

Prior to the start of a learning unit on natural resources, students completed a pre-assessment including 55 mixed method questions including true or false, multiple choice, fill-in-the-blank, and matching. While not used for research purposes historically, this assessment has been used for the previous 6 years by multiple teachers within the building or district and has yielded similar results each year. This suggests that the pretest is a reliable instrument that may be used for research purposes. Upon the end of the learning unit on natural resources, students completed a post-assessment using the same measurement tool. Instruction for the unit lasted approximately three weeks. Data was collected and secured by the researcher conducting the investigation personally.

Procedures

The specific intervention taking place over the instructional period was a change in teaching and learning styles. The control group participated in traditional learning methods using direct instruction, teacher-led activities, and remedial practice. The experimental group participated in project-based learning methods using individualized instruction, student-led activities, and student projects.

Data Analysis

In order to determine the effect of teaching or learning methods on student mastery of standards, the assessment data was analyzed using measures of central tendency. This included determining the mean, median, and mode assessment scores for both the traditional method and project-based method groups for comparison purposes. A calculation of the percent growth for students was determined, as well. In order to answer research question 2, ‘Will project-based learning improve student scores on an end of unit assessment?,’ a four-test factorial design was conducted. An independent sample t-test comparing the pre-assessment control group to the pre-assessment experimental group was used to determine whether all students began at the same level. A dependent sample paired t-test comparing the pre- and post-assessments of the control group determined whether there was a significant difference in control group scores. A dependent sample paired t-test comparing the pre- and post-assessments of the experimental group determined whether there was a significant difference in experimental group scores. An independent sample t-test comparing the post-assessment control group to the post-assessment experimental group determined whether project-based learning impacted student achievement.

In order to determine the level of rigor for both methods of instruction, statistical analysis including the average and range of Instructional Practices Inventory, or IPI, values was conducted. A qualitative comparison of the level of rigor according to Bloom's taxonomy was also evaluated to determine the highest level reached. For both the IPI values and Bloom's taxonomy, a mode was calculated to determine how a majority of instructional time was spent for each group in the study.

IRB Exemption

An exemption from the requirement of acquiring parental consent and student assent was granted by the Northwestern College Institutional Research Board because the research met the federal requirements of normal educational practice. The practice of using a project-based learning model as the primary methodology of instruction was evaluated compared to more traditional methods of instruction. Students completed various practices pertaining to learning targets and standards within the Next Generation Science Standards framework. This practice was implemented as part of research in order to determine if project-based learning has an effect on student mastery. Student data collected did not include identifiers for specific students. All names or personal information were removed as part of the research and its evaluation.

Data Collection

For the purpose of research, student data was collected using a pre- and post-assessment. The same 55-question mixed-method assessment was used prior to the learning unit and upon its completion. The role of this assessment was to determine a student's understanding of the scientific concept of natural resources as well as their ability to apply the skills and practices of the Next Generation Science Standards (NGSS). A total of 81 assessments were given each time, with 42 participants in the control group receiving traditional teaching or learning methods and 39 students in the experimental group receiving project-based learning methods. There were no outliers within this data set, resulting in all 81 assessments being counted for both the pre- and post-assessment.

Analysis of the pre-assessment test scores yielded the following data (See Table 2). For the control group participating in traditional learning, a high score of 36 points out of 55 total possible points and a low score of 22 points were recorded. The average pre-assessment score was 29.4 points overall with a median and mode score of 30 points. For the experimental group participating in project-based learning, a high score of 41 points and a low score of 22 points were recorded, out of 55 points possible. The average pre-assessment score was 30 points overall with a median score of 30 and a mode score of 28 points.

Analysis of the post-assessment test scores yielded the following data (See Table 3). For the control group participating in traditional learning, a high score of 53 points and a low score of 31 points were recorded out of 55. The average post-assessment score was 45.3 points overall with a median and mode score of 47 points. For the experimental group participating in project-based learning, a high score of 55 points and a low score of 34 points were recorded, out of 55 points possible. The average post-assessment score was 48.1 points overall with a median score of 49 points and a mode score of 53 points.

The level of rigor for learning tasks was categorized based on the Instructional Practices Inventory (IPI) and Bloom's Taxonomy. The Instructional Practices Inventory is a teacher-driven data collection based on the level of student engagement during a learning activity. Data for the IPI ranges from category 1 in which students are not engaged in learning related to the curriculum, to category 6 in which students are actively engaged in higher-order thinking through analysis, problem solving, critical thinking, creativity, and/or synthesis. Bloom's Taxonomy is a method for categorizing learning tasks based on an evaluation of the complexity of a learning activity ranging from low-complexity, remembering, in which students recall information to high-complexity, creating, in which students create original work.

Table 1

Categorization of the Level of Rigor for Learning Activities

Traditional Learning Group		Project-Based Learning Group	
Task	**Level of Rigor**	**Task**	**Level of Rigor**
Activity: Natural Resources Pre-Test	IPI Category[1]: 2 Bloom's Taxonomy[2]: Remembering	Activity: Natural Resources Pre-Test	IPI Category: 2 Bloom's Taxonomy: Remembering
Notes: What is a natural resource?	IPI Category: 4 Bloom's Taxonomy: Understanding	Project: Determine what is a natural resource	IPI Category: 5 Bloom's Taxonomy: Applying
Activity: Catalog the types of resources.	IPI Category: 3 Bloom's Taxonomy: Applying	Project: Identify types of resources	IPI Category: 5 Bloom's Taxonomy: Analyzing
Notes: Mining; How do we get our resources?	IPI Category: 4 Bloom's Taxonomy: Understanding	Project: Explain how natural resources are mined	IPI Category: 5 Bloom's Taxonomy: Understanding
Activity: Resource Availability	IPI Category: 3 Bloom's Taxonomy: Applying	Project: Measure the availability of natural resources	IPI Category: 5 Bloom's Taxonomy: Evaluating
Notes: Comparing Resources	IPI Category: 4 Bloom's Taxonomy: Understanding	Project: Evaluate various types of natural resources	IPI Category: 5 Bloom's Taxonomy: Evaluating
Activity: Energy Resources Compromise	IPI Category: 5 Bloom's Taxonomy: Applying	Project: Design a solution to our energy resource needs	IPI Category: 5 Bloom's Taxonomy: Creating
Activity: Natural Resources Review	IPI Category: 3 Bloom's Taxonomy: Remembering	Activity: Natural Resources Review	IPI Category: 3 Bloom's Taxonomy: Remembering
Activity: Natural Resources Post-Test	IPI Category: 2 Bloom's Taxonomy: Remembering	Activity: Natural Resources Post-Test	IPI Category: 2 Bloom's Taxonomy: Remembering

[1]: Instructional Practices Inventory, or IPI, is a measure of the level of student engagement within the classroom. For more information, visit: https://ipistudentengagement.com/ipi-process-in-depth/categories

[2]: Bloom's Taxonomy is a measure of the level of rigor based on a hierarchy of cognitive skills. For more information, visit: https://www.teachthought.com/learning/

Table 2

Traditional and Project-Based Learning Pre-Assessment Data

Traditional Learning Group			Project-Based Learning Group		
Student	**Score (Out of 55)**	**Proficiency**	**Student**	**Score (Out of 55)**	**Proficiency**
6A	24 (44%)	N	3A	35 (64%)	N
6B	29 (53%)	N	3B	30 (55%)	N
6C	36 (65%)	N	3C	26 (47%)	N
6D	30 (55%)	N	3D	33 (60%)	N
6E	30 (55%)	N	3E	31 (56%)	N
6F	32 (58%)	N	3F	29 (53%)	N
6G	29 (53%)	N	3H	35 (64%)	N
6H	31 (56%)	N	3I	31 (56%)	N
6I	28 (51%)	N	3J	33 (60%)	N
6J	25 (45%)	N	3K	28 (51%)	N
6K	33 (60%)	N	3L	24 (44%)	N
6L	30 (55%)	N	3M	22 (40%)	N
6M	27 (49%)	N	3N	28 (51%)	N
6N	31 (56%)	N	3O	31 (56%)	N
6O	30 (55%)	N	3P	26 (47%)	N
6P	29 (53%)	N	3Q	30 (55%)	N
6Q	26 (47%)	N	4A	28 (51%)	N
6R	30 (55%)	N	4B	36 (65%)	N
6S	25 (45%)	N	4C	31 (56%)	N
6T	22 (40%)	N	4D	33 (60%)	N
6U	35 (64%)	N	4E	34 (62%)	N
6V	29 (53%)	N	4F	40 (73%)	N
7A	31 (56%)	N	4G	28 (51%)	N
7B	26 (47%)	N	4H	24 (44%)	N
7C	28 (51%)	N	4I	32 (58%)	N
7D	26 (47%)	N	4J	33 (60%)	N
7E	28 (51%)	N	4K	28 (51%)	N
7F	30 (55%)	N	4L	31 (56%)	N
7G	33 (60%)	N	4M	28 (51%)	N
7H	31 (56%)	N	4N	25 (45%)	N
7I	30 (55%)	N	4O	28 (51%)	N
7J	32 (58%)	N	4P	41 (75%)	Y
7K	34 (62%)	N	4Q	29 (53%)	N
7L	28 (51%)	N	4R	25 (45%)	N
7M	26 (47%)	N	4S	26 (47%)	N
7N	35 (64%)	N	4T	34 (62%)	N
7O	33 (60%)	N	4U	26 (47%)	N
7P	29 (53%)	N	4V	31 (56%)	N
7Q	31 (56%)	N	4W	27 (49%)	N
7R	24 (44%)	N			
7S	28 (51%)	N			
7T	30 (55%)	N			

Table 3

Traditional and Project-Based Learning Post-Assessment Data

Traditional Learning Group			Project-Based Learning Group		
Student	**Score (Out of 55)**	**Proficiency**	**Student**	**Score (Out of 55)**	**Proficiency**
6A	39 (71%)	N	3A	54 (98%)	Y
6B	40 (73%)	N	3B	49 (89%)	Y
6C	51 (93%)	Y	3C	37 (67%)	N
6D	47 (85%)	Y	3D	52 (95%)	Y
6E	49 (89%)	Y	3E	49 (89%)	Y
6F	52 (95%)	Y	3F	50 (91%)	Y
6G	45 (82%)	Y	3H	53 (96%)	Y
6H	47 (85%)	Y	3I	51 (93%)	Y
6I	46 (84%)	Y	3J	53 (96%)	Y
6J	33 (60%)	N	3K	47 (85%)	Y
6K	52 (95%)	Y	3L	42 (76%)	Y
6L	51 (93%)	Y	3M	34 (62%)	N
6M	34 (62%)	N	3N	48 (87%)	Y
6N	50 (91%)	Y	3O	53 (96%)	Y
6O	47 (85%)	Y	3P	41 (75%)	Y
6P	45 (82%)	Y	3Q	50 (91%)	Y
6Q	43 (78%)	Y	4A	45 (82%)	Y
6R	47 (85%)	Y	4B	54 (98%)	Y
6S	35 (64%)	N	4C	50 (91%)	Y
6T	36 (65%)	N	4D	52 (95%)	Y
6U	52 (95%)	Y	4E	53 (96%)	Y
6V	44 (80%)	Y	4F	54 (98%)	Y
7A	47 (85%)	Y	4G	40 (73%)	Y
7B	43 (82%)	Y	4H	42 (75%)	Y
7C	47 (85%)	Y	4I	53 (96%)	Y
7D	35 (64%)	N	4J	52 (95%)	Y
7E	46 (84%)	Y	4K	42 (76%)	Y
7F	51 (93%)	Y	4L	49 (89%)	Y
7G	46 (84%)	Y	4M	46 (84%)	Y
7H	50 (91%)	Y	4N	42 (76%)	Y
7I	49 (89%)	Y	4O	48 (87%)	Y
7J	53 (96%)	Y	4P	55 (100%)	Y
7K	52 (95%)	Y	4Q	48 (87%)	Y
7L	46 (84%)	Y	4R	43 (78%)	Y
7M	31 (56%)	N	4S	44 (80%)	Y
7N	51 (93%)	Y	4T	53 (96%)	Y
7O	49 (89%)	Y	4U	46 (84%)	Y
7P	44 (80%)	Y	4V	52 (95%)	Y
7Q	43 (78%)	Y	4W	50 (91%)	Y
7R	36 (65%)	N			
7S	48 (87%)	Y			
7T	50 (91%)	Y			

Data Analysis

A four-test factorial design of the pre- and post-assessment data yielded the following results. Test 1, compared the pre-assessment control group (*M*=29.4, *SD*=3.2, *N*=42) to the pre-assessment experimental group (*M*=30.0, *SD*=4.2, *N*=39). Results from an independent sample *t*-test determined there was no significant difference between the pre-assessment scores of the treatment or control group. All students began at the same level, $t(79)=-0.8$, $p=0.45$, two-tailed. Test 2, according to results from a dependent samples *t*-test, determined there was a significant difference between the control group pretest (*M*=29.4, *SD*=3.2, *N*=42) and posttest scores (*M*=45.3, *SD*=5.9, *N*=42), $t(41)=-26.4$, $p < 0.001$, two-tailed. Test 3, according to results from a dependent samples *t*-test, determined there was a significant difference between the experimental group pretest (*M*=30.0, *SD*=4.2, *N*=39) and posttest scores (*M*=48.1, *SD*=5.1, *N*=39), $t(38)=-41.5$, $p < 0.001$, two-tailed. Test 4, according to results from an independent samples *t*-test, determined project-based learning had a significant positive impact on student achievement compared to traditional instruction, $t(79)=-2.3$, $p=0.03$, two-tailed, based on posttest scores of the treatment group *(M=48.1, SD=5.1, N=39)* and posttest scores of the control group *(M=45.3, SD=5.9, N=42)*.

The average level of rigor for the learning tasks used in the control group according to the IPI was a 3.7 out of 6, with mode scores of category 3 and 4 overall. The highest level of rigor for the learning tasks used in the treatment group according to Bloom's Taxonomy was the level of application. The average level of rigor according to the Instructional Practices Inventory (IPI) was a 4.7, with a mode score of category 5. The highest level of rigor reached according to Bloom's taxonomy was the create level, with multiple activities falling under the categories of evaluate and analyze as well. Based on this analysis, the level of rigor for the project-based learning model was higher than that of traditional instruction.

Discussion

Summary of Major Findings

Data analysis shows that students participating in both traditional and project-based learning experienced an improvement in their understanding of Earth Science curriculum and Next Generation Science Standards, or NGSS, skills and practices according to pre- and post-assessment data. However, it can be concluded based on post-assessment data that students participating in project-based learning activities demonstrated statistically significant more growth than their peers in the control group participating in traditional learning activities.

The purpose of the study was to determine if the participation in project-based learning had an effect on student performance that would be represented by a greater increase in growth from pre- to post-assessment. According to the data, each student showed improvement from the pre- to post-assessment after learning had taken place. However, statistically, students within the experimental group showed greater improvement on their post-assessment than did the control group.

As a result, the answer to the research question: ‘Will project-based learning improve student scores on an end of unit assessment?’ was determined to be yes. Based on the results of this study, it can be concluded that project-based learning may improve student scores on an end of unit assessment over traditional learning methods. This agrees with prior research that found that project-based learning made a positive and significant impact on student achievement by improving assessment scores and increasing the retention of learning (Kanter, 2010) (Gerard, et al., 2010) (Hugerat, 2016).

Limitations of the Study

This study involved participants that had access to a personal device that was used to complete classroom learning activities. Technology was a major component of the daily lessons for both the control and experimental groups. Furthermore, as a result of the COVID-19 pandemic, instruction for this learning unit was done primarily through a virtual environment with only a small portion of each class having students who chose, and were able to, participate with class in person. Considerations for the use of technology and remote instruction should be reviewed for future research.

Further Study

Potential future research could include the expansion of the study to a larger sample size, including other subject areas and grade levels. Additional research could take into account the considerations for the limitations of this study and be done without the presence of remote instruction or without the use of technology.

Conclusion

The landscape of science education is one that is constantly in flux. As new and innovative scientific standards and practices emerge, current teaching methods must adapt in order to meet the needs of today's students. As the findings of this study and prior research suggest, the use of project-based learning in the classroom is more rigorous, allows for the integration of the Next Generation Science Standards, and the incorporation of 21st Century Skills which may improve student performance.

This research compared the rigor of project-based learning tasks with traditional learning tasks, and examined achievement differences between students taught with project-based learning and traditional instruction. The findings and limitations from this study will be used by the researcher for future consideration. As a result of the findings of this research, project-based learning will continue to be utilized in the future. It is believed that the exposure to project-based learning provides students with real-world problems and content-specific examples that improve engagement and allow for the application of skills and understanding of scientific curriculum within the Next Generation Science Standards (NGSS) framework.

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