*International Journal of Social Science and Economic Research*

ISSN: 2455-8834

Volume:07, Issue:11 "November 2022"

# TRADITIONAL LEARNING VS. PROJECT-BASED LEARNING: WHICH IS MORE EFFECTIVE IN TEACHING INDEPENDENT AND DEPENDENT PROBABILITY?

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DOI: 10.46609/IJSSER.2022.v07i11.018 URL: https://doi.org/10.46609/IJSSER.2022.v07i11.018

Received: 20 November 2022 / Accepted: 30 November 2022 / Published: 3 December 2022

## ABSTRACT

Project-based learning is a teaching method that helps students learn how to use their critical and creative thinking. Students practice using their 21st century skills and learn how to research. PBL is often compared to traditional learning and how they differ in success and mastery. The goal of the present research was to investigate whether or not project-based learning would help students learn independent and dependent probability better than learning the same topics using a more traditional learning method. 22 middle school students, all without prior knowledge on independent and dependent probability, participated in the present study. After initial teacher-led instruction on the topic, 11 practiced what they learned using traditional word problems and 11 practiced using project-based learning. Afterwards, students were given a 10-question post-test. The results show that students in the project-based learning group achieved higher scores on the post-test than did the control group students. The results suggest that project-based learning helps students understand and succeed in a topic such as independent and dependent probability.

## 1. Introduction

Statistics show that project-based learning (PBL) can help kids learn better. PBL is known as a very innovative approach to learning. Students learn to drive their own learning through inquiry (Bell, 2010). PBL students showed a significantly higher critical thinking ability (Holmes & Hwang, 2014). PBL also allows students to engage more in their learning and feel less bored.

### 1.1 Project-Based Learning Affects The Way Students Perform And Think

  

ISSN: 2455-8834

Volume:07, Issue:11 "November 2022"

PBL affects the way students think and respond to questions and problems. The way traditional students think is simpler, and they use a less out- of- the-box way of thinking to solve the answers. PBL students create more open-ended answers. PBL empowers them to learn skills of the 21st century that fosters curiosity (Majid et al., 2021). Previous research also suggests that students in project-based learning classrooms get higher scores than traditional classrooms (Krajcik & Blumenfeld, 2006). In traditional classes, students learn to solve problems in a very factual way. On the other hand, project-based learning students learn to focus on research. While many students have learned the way to solve problems through traditional teaching skills, it is clear that PBL helps students not only succeed, but also think in a sophisticated manner. This indicates that students of project-based learning will grow to be able to solve real world problems. PBL will help the new generation take on new, struggling problems of the upcoming future. This shows that project-based learning is all about learning product orientation. Project-based learning helps students understand the deeper meaning to a problem and be able to solve the underlying meaning behind real world problems. Traditional students not only lack many 21st century skills and traits, but they also lack "out of the box thinking". PBL students respond significantly better in open-ended questions than traditional students and that is why PBL students are better prepared for the real world.

### 1.2 Project-based learning Impacts On 21st Century Skills

Project-based learning helps students learn 21st skills such as teamwork, persistence, leadership, critical thinking, problem solving, writing, and flexibility (National Education Association, 2010). It is important to teach these skills to students extensively, so that they learn how to incorporate these skills into their lives. This is because these skills will help students succeed in so many areas in their futures. Teachers who used PBL taught 21st century skills more often and more extensively (Hixson et al., 2012). Previous studies have also shown that PBL is one such creative method to meet the needs of developing 21st century skills in underserved students (cf., Holmes, 2012).

### 1.3 Project-based learning and its Effectiveness

Project-based learning has been extensively applied and tested. Research shows positive attitudes among students (both online and in-class) toward project-based learning (Abuhmaid, 2020). Studies show that project-based learning gets students to think more deeply. The effectiveness is not only shown through scores, but through the way the students interact with PBL. An experiment conducted by Bilgin et al. (2015) showed that students in the treatment group (PBL) produced better performance on the Post-SEBS course placement test. The students in the treatment group expressed mostly positive

  

ISSN: 2455-8834

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opinions about the use of the PBL method. Another experiment conducted by Kimsesiz et al. (2017)shows that PBL instruction could increase English as a Foreign Language vocabulary learning gains when compared to common methods and young learners were observed to have been more active in PBL classes.

Based on the research above, the present research question is: will project-based learning help students in middle school learn and master independent and dependent probability in a more efficient way than traditional teaching? The hypothesis is that project-based learning will help students learn independent and dependent probability better than learning the same topics using a more traditional learning method.

## 2. Method

### 2.1 Participants

Participants were 22 middle school students who were recruited from Fairfax and Prince William counties in Virginia. None of them had previously learned independent and dependent probability. Eleven students each were randomly assigned to the control group (traditional) and the experimental group (project-based learning).

### 2.2 Materials

The materials in this experiment consisted of a pre-test, group practice, a word problem assignment, a practice essay, and a post-test. The pre-test had 4 questions, two involved independent probabilities and two involved dependent probabilities. The group practice had 10 practice questions, five involved independent probabilities and five involved dependent probabilities. The next was an assignment. The control group assignment consisted of 10 word problem practice questions. The experimental group assignment was an essay. The essay instructions were:

"You will be given two versions of a contest. For each version you have to create two scenarios about a contest. In each version, you are asked to calculate the probability of winning the contest, given the rules of the contest. Then, you are asked to write an essay explaining your solution and also explaining which version of the contest gives you a better chance of winning."

The actual word problem was:

"There is a contest at the park. There are only 20 contestants who are playing in the contest. There will be 10 rounds and each round you win, you get 10 points. The object of the game is to have the most points at the end and you will get a prize of $20. Figure out the probability of getting the most points and winning the game. (scenario 1)

  

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There is a contest at the park. There are only 20 contestants that are playing in the contest. There will be 10 rounds and each round you win, you get 10 points. But at the end of each round, 2 people with the least amount of points get eliminated. The object of the game is to have the most points at the end and you will get a prize of $20. Figure out the probability of getting the most points and winning the game. (scenario 2)

Figure out which game will give you the higher chance of winning the cash prize, the first version of the contest or the second version. This is a three paragraph essay that had to explain the probability of winning in each scenario and which one would give you the higher chance of winning."

The last material used was a post-test. This post test was the same for both groups. The post-test had 10 questions. The ten questions were all word problems covering all the material the students had just learned. Five involved independent probabilities and five involved dependent probabilities.

### 2.3 Procedure

The 22 participants were randomly assigned into two groups with 11 in each group. There was a control group that used the regular, traditional teaching methods. There was an experimental group that used project-based learning. All of the participants took a pre-test to test whether they already knew the topic. The pre-test had four questions, two involved independent probabilities and two involved dependent probabilities. After the pre-test, participants were given instruction for 1 hour and 30 minutes. All participants received the same amount of teaching time and the same teaching. During the lesson, students solved 10 practice world problems and received corrective instruction from the teacher. After they did the practice questions, participants received their assignment. Students received no help or guidelines during this assignment. The assignment for the control group was 10 word problems. The experimental group had to write an essay about an independent and dependent probability word problem. The assignment was to solve the word problem and write a three paragraph essay about their answer and how they arrived at it. The students also had to answer if they thought that the word problem demonstrated an independent or dependent probability scenario. This assignment was also scored out of 10 points. After the assignment was graded, the two groups worked on a 10 word problem post-test. The post-test was the same for both groups. The entire experiment was completed in a single session to prevent students from using outside resources.

  

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## Results

The pre-test was scored based on the number of questions the Participants answered correctly with a maximum score of 4. For the control group, the mean number of correct answers was 1.64 and for the experimental group, it was 1.27. This difference was not statistically significant ($t<1$).

Next, the overall post-test scores, shown in Table 1, were compared between the groups. As with the pretest, the post-test was scored based on the number of correctly answered questions with a maximum score of 10. Participants in the control condition scored, on average, 6.27, while those in the experimental condition scored, on average, 9.18. This difference was statistically significant, $t = 8.21$, $df = 20$, $p < .0001$ and in the predicted direction. Because all participants did not come to the experiment with absolutely no prior knowledge of the topic area, improvement scores were calculated for each participant by calculating the percent correct on the post-test minus percent correct on the pretest. These are also shown in Table 1. Participants in the control condition improved an average of 21.8 percentage points while those in the experimental group improved an average of 60 percentage points. This difference was statistically significant, $t = 3.32$, $df = 20$, $p < .005$ and was in the predicted direction.

**Table 1: Mean Post-test Scores By Condition**

| | Control Condition | Experimental Condition |
|---|---|---|
| Mean Post-test score | 6.27 | 9.18 |
| Mean Post-test - Pretest percentage correct score | 21.8 | 60 |

## Discussion

Project-based learning is a teaching method that involves hands-on thinking, critical thinking, 21st century skills, and real life problems. PBL has been studied and compared to traditional teaching to find out whether or not it helps students master topics in a more successful manner than traditional teaching. The present hypothesis is that project-based learning will help students learn independent and dependent probability better than learning the same topics using a more traditional learning method. The results support the hypothesis that students using PBL showed higher performance on a post-test than those taught a traditional way.

  

ISSN: 2455-8834

Volume:07, Issue:11 "November 2022"

In addition to potential improved performance, PBL can teach students to think more along the lines that real world practitioners do. Unlike students who are typically taught advanced mathematics material largely in the abstract (with word problems used on a supplemental basis), math practitioners operate almost exclusively in the realm of real-world problem solving where problems are largely unstructured and results of analyses are used to support decisions. This results in the development of different ways of thinking about problems whereby students rely largely on formulas whereas practitioners focus more on goal setting, structuring problems, and interpreting results (Onwona et al., 2022). In other words, practitioners apply their craft by working on projects. In doing so, they develop knowledge that is fundamentally different from students' knowledge. Leddo et al. (2022) developed an assessment methodology called Cognitive Structure Analysis (CSA) that measures not only problem solving performance but also the underlying concepts that people have. CSA assesses factual, procedural, problem solving strategy and rationale (the "why" behind the concepts) knowledge. Additional research could be done using the CSA technique to assess whether students engaged in project-based learning develop their subject matter knowledge in a way that more closely matches the knowledge of practitioners than students engaged in traditional learning. This research could also be extended to other subjects and grade levels to further investigate the benefits of PBL.

## Conclusion

Project-based learning is a new teaching method that is being studied and experimented on. It involves students learning topics in a creative and critical manner. Students that are taught in project-based learning manner practice using 21st century skills. Research suggests that project-based learning is a more successful teaching method than the traditional learning method. It shows that PBL helps students understand the topic with more efficiency and accuracy. Most topics are taught to students using the traditional method, even though PBL has been experimentally shown to be more effective. Therefore, project-based learning should be used more often to teach students topics for successful results and true understanding and mastery.

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