



PROJECT-BASED LEARNING VS. TRADITIONAL TEACHING: WHICH APPROACH FOSTERS BETTER UNDERSTANDING?

Dr Amita Solanki

Assistant Professor, Vidyavati Mukand Lal Girls PG College CCS University, Meerut

ABSTRACT This study contrasts standard classroom teaching versus project-based learning (PBL) on students' understanding, performance, mental load, and classroom behaviour in Indian computer science education. A quasi-experimental design with a control group examined the impact of ICT training on 55 sixth graders in an Indian public school. The experimental group learnt via project-based learning that valued student-initiated activities and group problem-solving under teacher leadership. Alternatively, the control group received the Indian-style lecture-based curriculum. Data was collected using academic achievement exams, cognitive load measures, and ClassDojo, a classroom-specific digital behaviour management tool. Cramer's V Coefficient was used to analyse behavioural data and Two-Factor ANOVA for Mixed Measures to quantify academic performance and cognitive load across six weeks of the intervention. We compared the two groups' positive and negative behaviour scores to assess class participation. The findings indicated that PBL students performed better academically and cooperated more in class than traditional students. However, the two training approaches had similar cognitive burdens for pupils. Based on these results, Project-Based Learning (PBL) in Indian classrooms may decrease mental load, increase student participation, and boost academic accomplishment. Project-based learning (PBL) is a potential way to improve students' understanding and engagement with fundamental computing concepts due to the National Education Policy (NEP) 2020's emphasis on hands-on and skill-based learning.

Keywords: Project-Based Learning (PBL), Traditional Teaching Methods, Academic Achievement, Cognitive Load, Student Understanding, Classroom Behavior, Programming Education, Student-Centered Learning, Instructional Strategies, Educational Outcomes

INTRODUCTION

In the ever-evolving educational landscape of today, selecting an effective teaching style is of the utmost importance since it influences the degree to which students are able to acquire and comprehend difficult concepts. Project-based learning (PBL) and conventional teaching methods are the two educational approaches that are at the centre of this conversation. Both of these approaches have garnered a lot of attention in recent years. The objective of project-based learning is to motivate students to take an active role in the learning process by tackling issues that are relevant to the real world, as opposed to just absorbing knowledge from a teacher in a spectator capacity. As educators look for methods to teach not just facts and numbers but also creativity, critical thinking, and active engagement, the debate over whether method is more effective in fostering understanding has become more important.

The traditional method of teaching, which is often referred to as lecture-based education, places a significant emphasis on the transmission of information directly from the teacher to the student. This approach has historically been the most popular in classrooms and continues to be widely used because of the efficacy it has in conveying content, particularly in educational settings that include a large number of students. Others, however, argue that it does not go far enough to cultivate higher-order cognitive talents such as analysis, synthesis, and application, and instead promotes passive learning[1].

On the other hand, the constructivist theory serves as the theoretical foundation for project-based learning. Within the framework of this theory, it is proposed that students gain knowledge by active engagement and experience in the actual world. Students are given the opportunity to take charge of their own education via the use of problem-based learning (PBL), which requires them to do research, analyse, and offer solutions to complex problems that include several disciplines. Multiple research [2][3] have shown that problem-based learning (PBL) has the ability to improve student motivation, understanding of difficult concepts, and memory retention. According to the findings of a meta-analysis conducted by[4], performance-based learning (PBL) significantly enhances academic achievement, particularly in STEM (science, technology, engineering, and mathematics) courses.

According to[5] , project-based learning (PBL) assists students in developing skills that are essential for the 21st century. These skills include effective communication, self-directed learning, and collaboration. The scalability and consistency of the outcomes of project-based learning (PBL) have been called into doubt owing to the difficulties associated with its implementation, which include teacher readiness, curricular alignment, and assessment approaches. The objective of this article is to explore and compare the effectiveness of traditional classroom education with project-based learning in terms of the development of students' conceptual understanding. Using a combination of empirical data and theoretical concepts, the main objective of the research is to determine the method that assists students in developing learning that is both meaningful and long-lasting.

OBJECTIVES

1. To evaluate how PBL and conventional instruction affect students' comprehension and performance.
2. To evaluate how these approaches affected the behaviour and cognitive load of the pupils.

METHOD

Participants of Study

For the purpose of this research, the majority of the participants (N=55) were elementary school students who were enrolled in the "Information and Communication Technology (ICT)" class during the second half of the 2017–2018 school year. There were 29 students in the experimental group, whereas there were 26 students in the control group compared to the experimental group. These categories were chosen in a manner that was completely arbitrary.

Table 1. Participant Demographics[6].

Gender	Experimental Group	Control Group
Female	17	16
Male	12	10
Total	29	26

Research Design

[7] reported a quasi-experimental study with unequal control groups before and after the test. Table 2 lists the study's design and data collection tools. Both groups took a preliminary academic achievement test. The experimental group used project-based learning, whereas the control group used traditional methods. These groups were given a cognitive load measure and observed for student behaviour throughout implementation. Both groups took the academic achievement exam again as a post-test.

Data Collection Tools

The Scratch Academic Achievement Test by [8] was employed in this study. The achievement test has 28 MCQs. With an average difficulty of 0.70 and a discriminating power of 0.33, the achievement test has 0.8 KR-20 dependability. The Cognitive Load Scale, developed by [9] and translated into Turkish by [10] was used to assess students' cognitive effort. The scale's Cronbach's Alpha internal consistency coefficient is 0.78 and its Spearman Brown split half-test correlation is 0.79. Likert scale has nine points. The single-item scale measures students' job or project effort. As part of implementation, students took the cognitive load test after each lesson. We assessed project-based learning's influence on students' positive and negative conduct using ClassDojo. After evaluating field studies, we chose positive and bad classroom actions and assigned point values. The implementation gave students points for good conduct and deducted for negative behaviour. The ClassDojo interactive board provided quick student conduct feedback throughout the lesson. ClassDojo tracked both groups' kids' conduct throughout installation.

Table 2. Research Methods and Data Gathering Instruments[11]

Group	Before the Implementation	During the Implementation	After the Implementation
Experimental Group (Project-Based Learning)	Academic Achievement Test (Pre-test)	Observation of Students' Behavior (ClassDojo) Cognitive Load Scale	Academic Achievement Test (Post-test)
Control Group	Academic Achievement Test (Pre-test)	Observation of Students' Behavior	Academic Achievement Test (Post-test)

(Traditional Teaching Method)		(ClassDojo) Cognitive Load Scale	
-------------------------------	--	----------------------------------	--

Data Analysis

The study's data was analysed using SPSS 20.0. The first research difficulty was addressed using a Two-Factor Anova for Mixed Measures. This study shows the implementation process's conditions (e.g., experimental and control groups) and characterises change over time (e.g., pretest-posttest). The experimental group employed project-based learning to assess students' academic achievement, whereas the control group used traditional techniques. Second, both groups were assessed before and after the study. Cognitive load data is classed. [12] employed nonparametric analysis to analyse cognitive stress data. Students' cognitive burden while learning programming via different educational techniques has nine components. When two categorical variables contain more than two categories, the Cramer V coefficient shows the change. The Chi-Square test of independence uses Cramer V to evaluate effect size. This statistic measures category domain connection. Therefore, the study's second research subject needed Cramer V coefficient calculation. We examined ClassDojo behaviour evaluations to answer the third study question. We evaluated the good behaviour percentages to see whether the difference was statistically significant. For significance testing, we may calculate the z-value by dividing the percentage difference between the two sets by its standard error. The normal distribution curve shows the z-value as the unit standard deviation. For .05 significance, a z-score must be 1.96 or above.

RESULT

The Academic Achievement Test's results

The Two-Factor ANOVA for Mixed Measures results are in Table 4, and Table 3 shows the average and standard deviation values for the first research question, which asked if traditional teaching methods or project-based learning affected students' academic achievement.

Table 3. Descriptive Statistics for Students in the Experimental and Control Groups' Programming Achievements[13].

Group	N	Pre-Test $\bar{X}$	S	N	Post-Test $\bar{X}$	S
Experimental Group (Project-Based Learning)	29	12.68	4.17	29	24.89	3.82
Control Group (Traditional Teaching)	26	13.30	5.51	26	20.76	3.72

Table 3 shows that the experimental group's average academic performance exam score increased from 12.68 to 24.89. This figure jumped from 13.30 to 20.76 for control students. These data show both groups improved academically. The experimental group changed pre- and post-test scores 12.21 points more than the control group (7.46 points).

Table 4. Two-Factor ANOVA for Mixed Measures Results[14].

Source of Variance	Sum of Squares	df (Sd)	Mean Square	F	p
Inter-subjects	981.854	54			
Group (Experimental/Control)	84.414	1	84.414	4.985	.030
Error	897.440	53	16.933		
Intra-subjects	3915.627	55			
Measurement (Pretest/Posttest)	2651.663	1	2651.663	126.655	.000
Group * Measurement	154.354	1	154.354	7.373	.009
Error	1109.610	53	20.936		
Total	4897.481	109			

Table 4 illustrates that the experimental and control groups had different academic results before and after two alternate teaching methods. Academic achievement was significantly linked to treatment group effects and repeated assessment factors [$F(1-53) = 7.373, p < .05$]. Thus, project-based programming lessons are more successful for pupils. Only two programming education methods were tested for classroom improvement. Thus, the common impact test of factors and groups was prioritised. The group and measurement undergo basic impact testing for the inquiry. Participants taught utilising project-based and traditional techniques had significantly different pre- and post-test scores, as shown by the results of the two basic impact tests [$F(1-53) = 4.985, p < .05$]. This test will not account for pre- and post-test group switching. There was a significant difference in participants' academic performance ratings before and after the examination, independent of group identity ($F(1-36) = 126.655, p < .05$). This shows that, without group discrimination, programming teaching methods affect students' final projects.

Results on Measuring Cognitive Load

The findings of the Cramer V Test are shown in Table 5, which pertains to the second research question, which asked whether there was a significant difference in students' cognitive load when exposed to project-based learning versus conventional instruction.

Table 5. Testing Results for Cramer V[15].

Item	Concept	Cramer's V Value	p-value
Item 1	Linear logic structure	.323	.454

Item 2	Motion panel	.451	.083
Item 3	Events panel	.221	.846
Item 4	Sound panel	.418	.143
Item 5	Pen panel	.466	.102
Item 6	Loop structure	.372	.269
Item 7	Looks panel	.320	.464
Item 8	Sensing panel	.356	.325
Item 9	Data panel	.337	.397
Item 10	Decision structure	.527	.018
Item 11	Operators panel	.449	.135

Table 5 shows no statistical significance owing to the low Cramer V value. However, the Cramer V value was significant ($p < 0.05$) when students were asked about their effort in understanding decision structure. The cognitive load for this question was considerably different for experimental and control students. In short, the experimental group knew about "decision structures" in the programming course but was less intellectually challenging than the control group.

Results on the Alteration of Behaviour

ClassDojo was used to collect and analyse students' behavioural scores to answer the third study question, which asked if project-based learning and conventional teaching methods affected in-class behaviour. Good conduct earned pupils favourable behaviour ratings, while poor behaviour earned them negative behaviour scores. Results were posted to students' ClassDojo profiles. Both sets of students' "behaviour that needs improvement" evaluations were determined by ClassDojo. Before the trial, Figure 1 illustrates the groups' four-week behaviour scores.

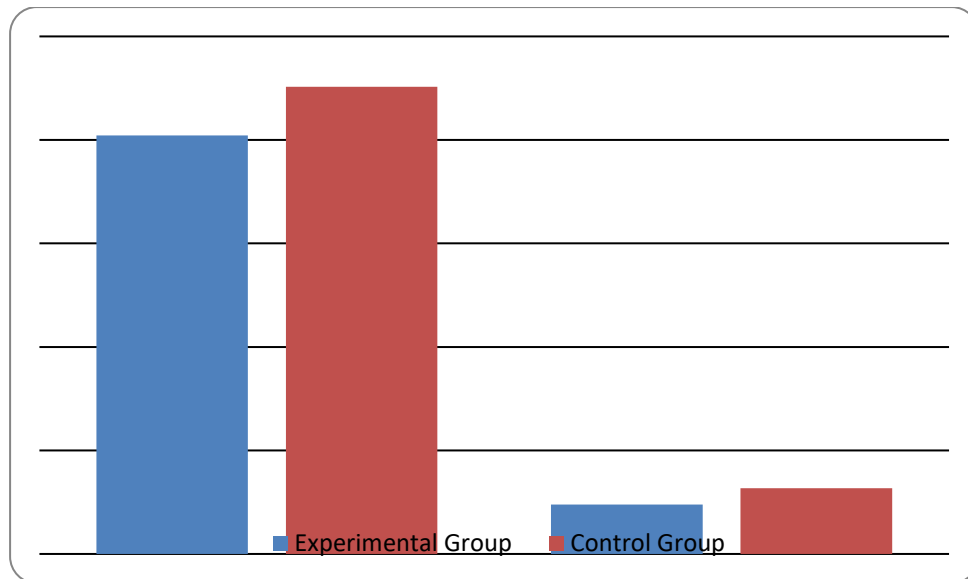


Figure 1. Group Four-week Behaviour Scores Before Experiment[16].

Figure 1 indicates that 2022 of 2261 behaviours are positive in the experimental group and 2256 in the control group. Since their total behaviour ratings are different, the two groups' positive behaviour percentages may be compared. The percentage of groups' four-week behaviour ratings before the experimental procedure is shown in Figure 2.

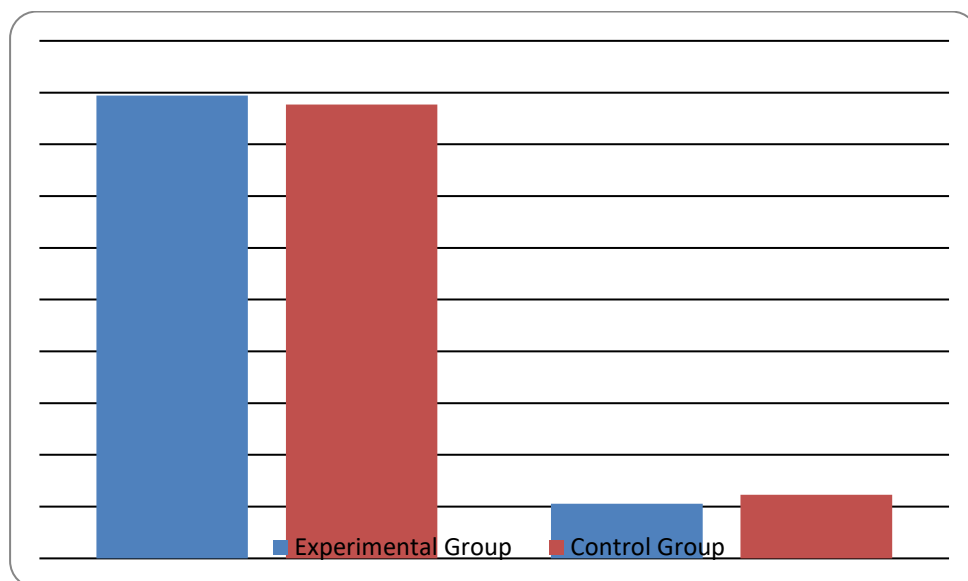


Figure 2. Group Four-week Behaviour Score Percentages Before Experimental Procedure[17].

Figure 2 shows that the experimental group had 89.42% "positive behaviour" and the control group 87.67%. This difference in "positive behaviour" percentages across groups is statistically significant with a z-score of 1.90. The critical ratio was below 1.96, the threshold for statistical significance at .05. Thus, the two percentages are not statistically different at .05. Thus, before the experiment, the two universes' percentages were similar. Figure 3 shows the six-week behavioural scores from both groups in the trial.

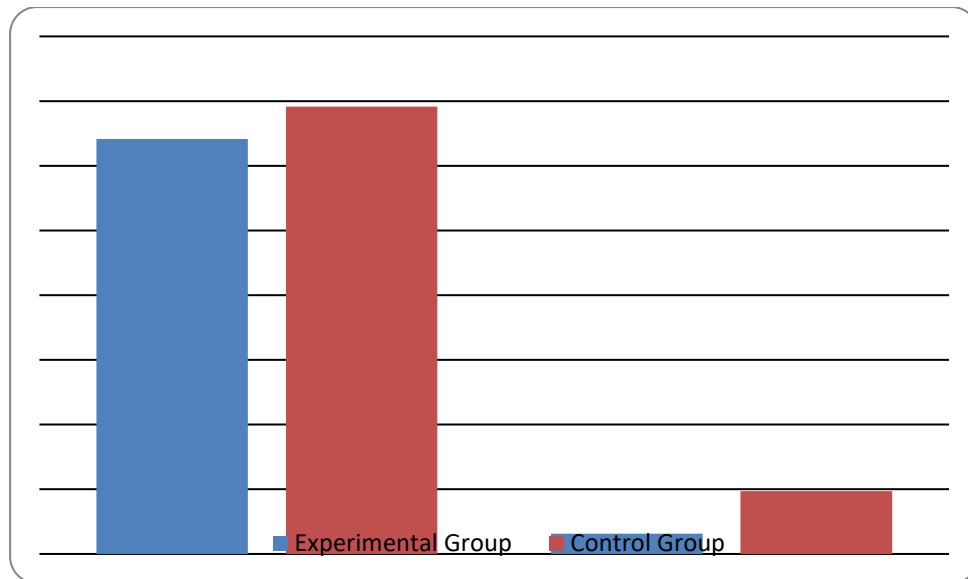


Figure 3. The Experimental Procedure's Six-Week Behaviour Scores for the Groups[18].

Figure 3 shows that 1283 of 1346 experimental behaviours are positive, whereas 1383 of 1577 control behaviours are positive. The two groups' positive behaviour percentages could be compared since their total behaviour ratings were different. Figure 4 shows the experimental procedure's six-week behaviour percentages for each group.

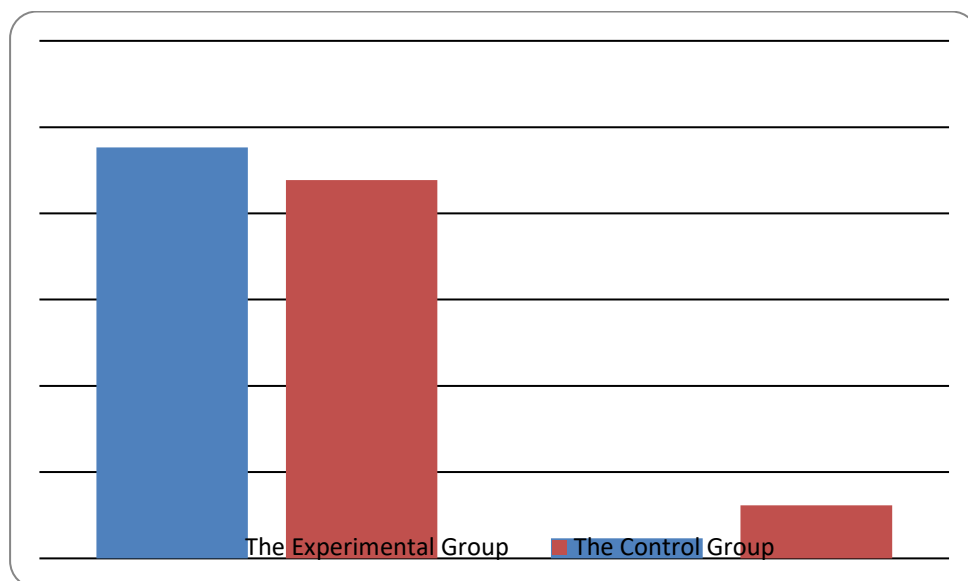


Figure 4. The Six-week Behavior Percentages of the Groups During the Experimental Procedure[19].

When Figure 4 is examined, it is seen that the percentages of “positive behavior” are 95.31% in the experimental group and 87.67% in the control group. The statistical significance of the difference between the percentages of “positive behavior” of the two groups was tested and found to be $z = 7.25$. This critical ratio value calculated is higher than 1.96 which is required for the significance of .05. Thus, it can be accepted that there is a difference between two percentages during the experimental procedure. It can be

said that the experimental group students were more successful than the control group students in terms of "positive behavior" percentage. The extent to which the "positive behavior" percentages of students increased when they worked on a task and to what extent the percentages of "behavior that needs improvement" decreased were examined. The percentages of the experimental group's "positive behavior" and "behavior that needs improvement" scores before and during the experimental procedure are given in Figure 5.

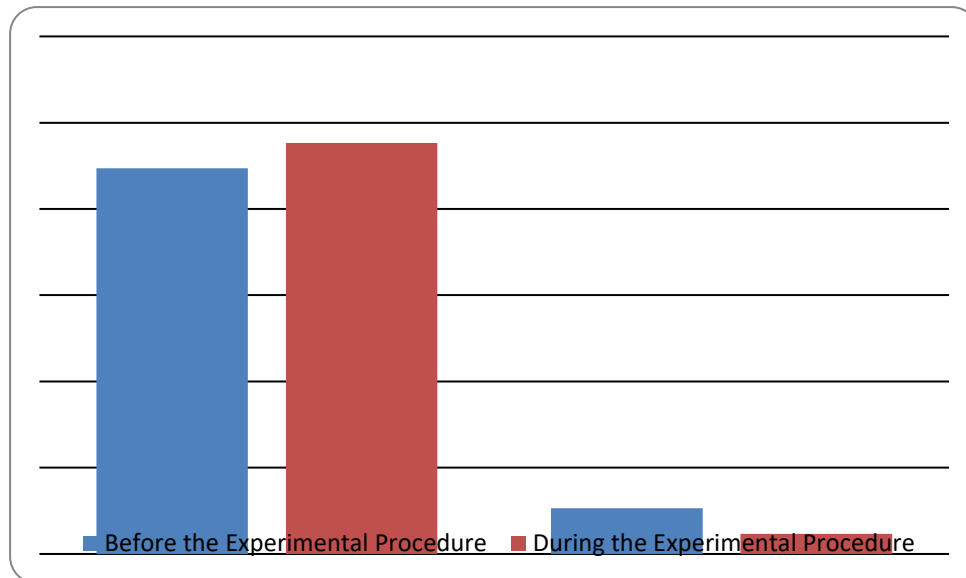


Figure 5. Scores for "Positive Behaviour" and "Behaviour That Needs Improvement" as a Percentage in the Experimental Group

Figure 5 demonstrates that "positive behaviour" rose from 89.42% before the procedure to 95.31% after. Before the procedure, 10.57% of experimental group students had "behaviour that needs improvement"; thereafter, 4.68% did. Comparing the two methods' behaviour percentages, the experimental application approach is 6% better. This implies that project-based learning in computer science curriculum enhances classroom atmosphere by boosting constructive student behaviour and minimising disruptive ones.

DISCUSSION

Specifically with regard to the field of programming education, the findings of this study contribute to the ongoing debate about the question of whether or not Project-Based Learning (PBL) or Traditional Teaching Methods is more effective in enhancing student understanding. In terms of academic achievement, students who were taught utilising PBL did better than those who were taught using more traditional methods of instruction. The fact that this is the case demonstrates that project-based learning (PBL) offers pupils an exceptional educational chance to comprehend abstract concepts and put their learnt knowledge into reality. PBL's active engagement, problem-solving, and real-world context allow students to better internalise abstract programming principles than lecture-based learning can. This is because PBL encourages students to actively participate in the learning process. Previous [20-22] has emphasised the advantages of student-centered, experiential learning strategies in encouraging deeper understanding. Our findings are in agreement with these findings, indicating that these techniques are beneficial in fostering deeper comprehension.

Even though there was a discernible gain in academic success, students who were taught using PBL did not have a substantially reduced cognitive load when compared to those who were taught using traditional techniques. In especially for younger students who are studying programming for the first time, the complexity and novelty of the subject matter might be a possible explanation for this result. As a result of the high cognitive load, it is possible that the challenges associated with learning programming will have a higher influence on both groups than the differences in the instructional approaches used at the beginning. Research has demonstrated that beginner programmers experience mental fatigue while attempting to acquire new terminology, integrate mathematical ideas, and employ logical reasoning[23][24]. This is because novice programmers are already struggling to learn these things. Furthermore, the cognitive demands of switching to the collaborative and autonomous nature of PBL may initially negate the potential reduction in cognitive load that PBL is often recognised for. This is because PBL is characterised by a combination of collaborative and independent work.

The implementation of project-based learning (PBL) resulted in considerable gains in students' involvement, attention, collaboration, and task completion, as shown by data gathered by ClassDojo. On the other hand, a bigger number of students in the group that received traditional instruction exhibited behaviours that may be affected by some degree of improvement. This study demonstrates that project-based learning (PBL) does more than only keep students' heads engaged; it also drives them to put their emotions and actions into what they are learning that they are receiving. On the surface, it would seem that the framework of project-based learning (PBL), which includes autonomy, accountability, and meaningful projects, is responsible for fostering better classroom conduct. According to[25], who provided backing for these findings, it was shown that the use of project-based classroom management practices led to improvements in both the behaviour and motivation of students.

Students were able to monitor and regulate their own behaviour with the use of digital tools like ClassDojo, which further stressed the importance of good conduct behaviour. The effectiveness of ClassDojo has been the topic of a variety of results in several studies[26][27], which suggests that the deployment of such tools may affect the behavioural impacts. The outcomes of the research lend credence to the notion that problem-based learning (PBL) is the most effective method of teaching programming since it boosts both student knowledge and involvement. The educational impact of PBL is shown by the improvements in achievement and behaviour, despite the fact that beginning students continue to struggle with the cognitive demands of the activity. The findings of this study show the need of providing additional scaffolding when implementing project-based learning (PBL) in advanced courses, especially for students who are not acquainted with the subject matter or the method of learning. Possible pathways for additional inquiry into improving learning outcomes and cognitive load management include a more gradual introduction to PBL or hybrid models that mix the two methodologies. Both of these approaches are possible results of further investigation.

CONCLUSION

The study primarily focused on academic performance, cognitive load, and classroom behaviour as they related to the effectiveness of Project-Based Learning (PBL) vs Traditional Teaching Methods in assisting students in comprehending programming. Specifically, the research compared the two approaches. The results of the study indicate that, in comparison to traditional education, problem-based learning (PBL) significantly enhances academic attainment and encourages more pleasant classroom behaviours.

According to these findings, students are able to acquire a more profound comprehension of complex concepts by cooperating with one another on projects, participating in active research, and finding solutions to issues that are based on the real world. However, the study also found that problem-based learning (PBL) did not significantly reduce cognitive load. This suggests that learners may still have challenges owing to the unfamiliarity of the approach and the initial difficulty of programming. In spite of this, the greater levels of involvement and effort that were shown by the PBL group indicate that the students were more involved in their own learning and, hence, had superior academic achievements. But certainly not least, as compared to more traditional methods of education, Project-Based Learning encourages better levels of engagement and understanding. Providing students with the opportunity to learn programming and other related subjects in this manner is an excellent technique to assist them in developing the critical thinking and problem-solving skills that are required by businesses. In the long term, project-based learning has the potential to change classroom dynamics and improve learning outcomes when it is applied correctly.

REFERENCES

- [1] Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, 93(3), 223–231.
- [2] Thomas, J. W. (2000). A review of research on project-based learning. The Autodesk Foundation.
- [3] Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. The Clearing House, 83(2), 39–43. <https://doi.org/10.1080/00098650903505415>
- [4] Han, S., Capraro, R., & Capraro, M. M. (2021). How science, technology, engineering and mathematics (STEM) project-based learning affects high, middle and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education*, 19(3), 667–686. <https://doi.org/10.1007/s10763-020-10109-2>
- [5] Condliffe, B., Quint, J., Visher, M. G., Bangser, M. R., Drohojowska, S., Saco, L., & Nelson, E. (2017). Project-Based Learning: A Literature Review. MDRC.
- [6] Albanese, M. A., & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, 68, 52–81
- [7] Karasar, N. (2017). Bilimsel araştırma yöntemi: kavramlar, ilkeler, teknikler (32.baskı). Ankara: Nobel.
- [8] Yüksel, S. (2017). Scratch programı öğretiminde ayrılıp birleşme tekniği kullanımının öğrencilerin derse yönelik tutumuna, akademik başarısına ve kalıcılığa etkisi (Unpublished master thesis). Adnan Menderes University, Aydın.
- [9] Paas, F. G., & Van Merriënboer, J. J. (1993). The efficiency of instructional conditions: An approach to combine mental effort and performance measures. *Human factors*, 35(4), 737-743. doi: 10.1177/001872089303500412

- [10] Kılıç, A. G. E., & Karadeniz, Ö. G. Ş. (2004). Hiper ortamlarda öğrencilerin bilişsel yüklenme ve kaybolma düzeylerinin belirlenmesi. *Kuram ve Uygulamada Eğitim Yönetimi*, 40(40), 562- 579.
- [11] Ala-Mutka, K. (2004). Problems in learning and teaching programming-a literature study for developing visualizations in the Codewitz-Minerva project. *Codewitz needs analysis*, 20.
- [12] Büyüköztürk, Ş. (2016). Sosyal bilimler için veri analizi el kitabı (22. baskı). Ankara: Pegem Akademi.
- [13] Anastasiadou, S. D., & Karakos, A. S. (2011). The beliefs of electrical and computer engineering students' regarding computer programming. *The International Journal of Technology, Knowledge and Society*, 7(1), 37-51.
- [14] Askar, P., & Davenport, D. (2009). An investigation of factors related to self-efficacy for Java Programming among engineering students. *The Turkish Online Journal of Educational Technology*, 8(1)
- [15] Byrne, P., & Lyons, G. (2001). The effect of student attributes on success in programming. *ACM SIGCSE Bulletin*, 33(3), 49-52.]
- [16] Clark, R. C., Nguyen, F., & Sweller, J. (2011). *Efficiency in learning: Evidence-based guidelines to manage cognitive load*. John Wiley & Sons
- [17] Dabbagh, N., & Denisar, K. (2005). Assessing team-based instructional design problem solutions of hierarchical versus heterarchical web-based hypermedia cases. *Educational technology research and development*, 53(2), 5-22.
- [18] Farkas, D., & Murthy, N. (2005). Attitudes toward computers, the introductory course and recruiting new majors: Preliminary results. In 17th Workshop of the Psychology of Programming Interest Group, Sussex University (pp. 268-277)
- [19] Garcia, E., & Hoang, D. (2015). Positive behavior supports: Using Class Dojo as a token economy point system to encourage and maintain good behaviors. *Online Submission*, 1-7.
- [20] Atıcı, B., & Polat, H. (2010). Web tasarımı öğretiminde proje tabanlı öğrenme yaklaşımının öğrencilerin akademik başarısı ve görüşlerine etkisi. *Turkish Journal of Computer and Mathematics Education*, 1(2), 122-132
- [21] Dede, D. (2008). Bilgisayar destekli proje tabanlı öğretim ile geleneksel proje tabanlı öğretim stratejilerinin, öğrencilerin fen bilgisi ve bilgisayar dersi akademik başarılarına ve portfolyo değerlendirme sonuçlarına etkilerinin karşılaştırılması (Unpublished master thesis). Marmara University, Istanbul
- [22] Peng, J., Wang, M., & Sampson, D. (2017). Scaffolding project-based learning of computer programming in an online learning environment. In 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT) (pp.315-319). IEEE. doi: 10.1109/ICALT.2017.1

- [23] Lahtinen, E., Ala-Mutka, K., & Jarvinen, H. M. (2005). A study of the difficulties of novice programmers. *Acm Sigcse Bulletin*, 37(3), 14-18. doi: 10.1145 / 1067445.106745
- [24] Wang, L., & Chen, M. (2010). The effects of game strategy and preference-matching on flow experience and programming performance in gamebased learning. *Innovations in Education and Teaching International*, 47(1), 39-52. Doi: 10.1080/14703290903525838
- [25] Redmond, K. (2014). The effects of project-based learning on student achievement in a fourth grade classroom (Unpublished master thesis). Montana State University Bozeman, Montana
- [26] Elliott, C. (2017). Increasing student perceptions of teacher caring using class dojo (Unpublished master thesis). California State University, Monterey Bay.
- [27] Ward, J. J. (2015). The effect of Classdojo and Go Noodle on the behavioral and off-task disruptions of third grade students (Unpublished master thesis). Goucher College, Graduate Programs in Education.