ETDC Indonesian Journal of Research and Educational Review
Volume 4, No. 1, 2024, pp 57 - 67
e–ISSN 2809-3682
p–ISSN 2809-7505

https://doi.org/10.51574/ijrer.v4i1.2689

SECONDARY SCHOOL LEARNERS' PERCEPTIONS OF THE IMPACT OF PROJECT-BASED LEARNING ON ACADEMIC PERFORMANCE

Efayena Trustee
Institute of Education Delta State University Abraka, Nigeria

Article Info

Article history:

Received October 15, 2024
Revised December 09, 2024
Accepted December 16, 2024

Keywords:

Academic Achievement;
Project Based Learning;
Perceptions;
Secondary School Learners'.

ABSTRACT

The study investigated students' perceptions of project-based learning and academic performance in secondary schools. The study is an ex post facto research design. The population of the study was 308 Senior Secondary School 3 students (SS3), and a sample of 220 students was selected employing the multi-stage sampling technique. The instrument for the study was a questionnaire. The reliability of the instrument was 0.77. Researchers analyzed the collected data using the mean score. The findings showed that senior secondary school students believe the project-based learning method improves all important aspects of their learning; it has a big positive effect on their academic performance; and it develops skills like leadership, problem-solving, adaptability, initiative, self-direction and autonomy, teamwork, the ability to learn on your own, and excellent communication, among others. Based on the findings, it was recommended, among other things, that educators and school administrators should prioritize the adoption and integration of project-based learning methods into the curriculum.

Corresponding Author:

Efayena Trustee,
Institute of Education Delta State University Abraka, Nigeria
Email: efayenat@delsu.edu.ng

1. INTRODUCTION

Within the traditional framework of public secondary schools, conventional teaching methods have long been the norm; however, project-based learning (PBL) has emerged as a promising alternative to lecture methods, offering a dynamic and student-centred method of education. PBL involves students working collaboratively on real-world projects, where they actively engage in inquiry, critical thinking, and hands-on problem-solving. Granado-Alcón et al. (2020); Chimwayange (2024); Wijnia et al. (2024) in their studies found that students overwhelmingly favoured PBL, citing increased engagement, relevance to real-world contexts, and deeper understanding of content as primary reasons.

Kokotsaki et al. (2016); Liu et al. (2019), Zhang et al. (2024) found that students expressed a preference for PBL due to its hands-on nature, opportunities for creativity,

and ability to foster a deeper connection with the subject matter. Likewise, the study by Nguyen (2017) reported a positive correlation between participation in PBL projects and students' perceived preparedness for future careers, problem-solving abilities, and industry relevance fostered by PBL experiences—fostering collaboration, deep learning experience, etc. Project-based learning (PBL) has become popular in education because it helps students improve their academic performance. This method encourages active participation, solving real problems, and working together with others. PBL stands in contrast to lecture methods by immersing students in hands-on projects that require critical thinking, creativity, and application of knowledge (Pan et al., 2023).

As educators and policymakers seek innovative strategies to improve student outcomes, understanding the extent to which the implementation of PBL impacts academic achievement becomes paramount. Research suggests that the implementation of PBL methods has a profound impact on students' academic achievement across various subject areas and grade levels. Wang et al. (2023), in a longitudinal study, aimed to investigate the impact of project-based learning (PBL) on academic achievement and found that students exposed to PBL demonstrated significantly higher levels of academic achievement compared to their peers in traditional classrooms. In another study, Aifan (2022) findings indicated that PBL promotes digital literacy, problem-solving skills, and collaborative learning, which are essential for success in the 21st-century workforce. Chen & Yang (2019) meta-analysis studies on the effectiveness of PBL in improving student academic achievement across various subject areas discovered that PBL is associated with positive outcomes in terms of content mastery, problem-solving skills, and overall academic performance.

Project-based learning has emerged as a prominent pedagogical method in public secondary schools, revolutionising traditional classroom dynamics by offering students immersive and experiential learning opportunities (Bielik et al., 2022; Martinez, 2022). Rooted in the principles of inquiry and hands-on exploration, PBL engages students in the investigation and resolution of genuine, real-world problems, as emphasised by Chang et al. (2024). This methodology transcends rote memorisation by inviting students to delve into complex issues that mirror the challenges they may encounter outside the classroom walls. At the heart of PBL lies the fusion of content knowledge acquisition with the development of essential skills indispensable for thriving in the 21st-century landscape. As Chang et al. (2024) assert, students not only deepen their understanding of academic subjects but also cultivate competencies crucial for success in an increasingly dynamic and interconnected world.

Maros et al. (2023), in a study that aimed to explore the specific competencies that students develop through project-based learning in public secondary schools, revealed that students developed a wide range of competencies through project-based learning. These included enhanced critical thinking. The project-based learning in public secondary schools plays a crucial role in fostering the development of specific competencies essential for success in the 21st century (Martinez, 2022; Rehman et al., 2024). Additionally, project-based learning helps students think more deeply by

encouraging them to analyse, create, and assess information. It also promotes teamwork and communication skills in public secondary schools.

Another key competency that students develop through project-based learning in public secondary schools is the enhancement of problem-solving abilities. Research by Feng et al. (2024) underscores how PBL tasks challenge students to navigate complex, ill-structured problems that require creative and adaptive solutions. According to Ngereja et al. (2020), PBL environments provide students with autonomy to explore their interests, set goals, and monitor their progress. In the same vein, Sasson et al. (2018) studies showed a statistically significant increase in critical thinking scores among students participating in PBL activities compared to those in control groups. The findings highlight the efficacy of PBL in promoting critical thinking skills and significant improvement in collaboration skills among participants engaged in PBL compared to those in traditional classrooms.

As educators seek to optimize teaching methodologies to meet the diverse needs of learners, understanding the effectiveness of PBL in this context becomes imperative. Research suggests that project-based learning holds promise for promoting deeper learning experiences among students in public secondary schools. For instance, a study by Duke et al. (2021) found that students engaged in PBL demonstrated improved problem-solving abilities and higher levels of motivation compared to those in traditional instructional settings. Similarly, Hussein (2021) observed enhanced collaboration and communication skills among students participating in project-based learning initiatives. These findings underscore the potential of PBL to foster 21st-century skills essential for academic success and future career readiness.

Smith & Brown (2021) assessed the effectiveness of project-based learning in public secondary schools over two years. The findings of the study revealed that PBL participants showed greater mastery of course content, improved critical thinking skills, and higher levels of motivation and interest in learning. Martinez et al. (2020) examined the impact of project-based learning on student success in public secondary schools by synthesising findings from multiple empirical studies, which revealed a significant positive effect of project-based learning on student success in public secondary schools.

The findings of a large-scale longitudinal study by Tirado-Morueta et al. (2022) clearly demonstrated a correlation between participation in PBL activities and increased levels of student engagement. Students reported feeling more motivated to learn and actively participate in class discussions and group projects when engaged in PBL engagement and motivation. Notably, students who engaged in PBL experiences demonstrated higher levels of retention of knowledge and deeper understanding of course content over time. Also, PBL participants showed a better ability to apply their skills in new situations, which means they had a stronger and more flexible learning experience (Chua & Islam, 2021; Rohm et al., 2021). Likewise, the study carried out by Nguyen et al. (2020) reported that students felt more enthusiastic about learning and expressed a greater sense of ownership over their education. Teachers also observed higher levels of student engagement and participation in class activities, indicating a more positive learning environment fostered by PBL (Nguyen et al., 2020).

Furthermore, Almulla (2020), in a qualitative study, explored the implementation of PBL in diverse classroom settings; they found PBL consistently fostered student engagement and academic growth. Teachers reported positive outcomes associated with PBL, including increased student motivation, collaboration, and critical thinking skills (Almulla, 2020). Kim (2020); He et al. (2023) studies' findings indicated that students who participated in PBL experiences outperformed their peers in terms of academic achievement and retention of knowledge. Additionally, PBL participants demonstrated higher levels of intrinsic motivation and a deeper understanding of the course material.

This study aims to understand how students view project-based learning compared to traditional lectures in public secondary schools in Delta State, Nigeria. It will look at how much project-based learning affects students' grades, identify the skills students gain from this method, and assess how effective project-based learning is in secondary schools.

The following research questions serve as the study's guide.

1. How do students perceive project-based learning methods in comparison to lecture methods in public secondary schools?
2. To what extent does the implementation of project-based learning methods impact students' academic achievement?
3. What are the specific competencies that students develop through project-based learning methods in public secondary schools?

2. METHOD

The study employed the ex-post facto research design. The population of the study was 308 Senior Secondary School three students (SS3), from which a sample of 220 were selected employing the multi-stage sampling technique. The instrument was a questionnaire titled 'Project-Based Learning Method" and Student Academic Achievement Questionnaire (PBLMSAAQ). A four-point rating scale of Strongly Agreed (SA=4), Agreed (A=3), Disagreed (D=2), and Strongly Disagreed (SD=1) was used to rate the opinion of respondents. We conducted face and content validation on the instrument. To ensure the reliability of the instrument, the test-retest method was utilized to establish its consistency.

The research instrument underwent a pilot test by distributing 20 copies of the questionnaire to secondary school students who were not within the study area twice, with a two-week interval between administrations. The data obtained from the pilot test underwent analysis using Pearson's Product Moment Correlation Coefficient (PPMC) to assess internal consistency, resulting in a reliability index of 0.77. The data collected were analyzed using descriptive statistics (frequency, percentage, and mean). We utilized a criterion of 2.50 to address the research questions.

3. RESULTS AND DISCUSSION

Results

Table 1. Learners' Perceptions of Project-based Learning Method in Comparison to Lecture Methods

SN	Items	SA	A	D	SD	Mean	Decision
1	PBL prepares students for the future compared to lecture methods	99	32	19	20	3.24	Agreed
2	PBL is more enjoyable than lecture method	91	52	10	17	3.28	Agreed
3	PBL encourages me to actively engage with the subject matter	85	41	11	33	3.05	Agreed
4	PBL does not give room for passive learning	81	33	10	46	2.88	Agreed
5	PBL allows me to apply what I learnt to real world situation	72	31	20	47	2.75	Agreed
6	PBL helps me to engage in critical thinking	30	97	33	10	2.86	Agreed
7	I can explore topics in greater depth with PBL compared to traditional method	19	115	20	16	2.81	Agreed
8	Lecture methods focus more on memorization than understanding of concepts	18	121	15	16	2.83	Agreed
9	PBL provides learners with opportunities for collaboration and teamwork	17	100	32	21	2.66	Agreed
10	I am more motivated to learn when engaging in PBL activities	16	110	33	11	2.77	Agreed
	Aggregate Mean					2.91	

Table 1 shows the aggregate mean of 2.91, which is higher than the criterion mean of 2.50. Also, the mean for each item above is higher than the 2.50 criterion mean. This implies that the learners perceive the PBL method of learning as better than the lecture method.

Table 2. Extent to Implementation of PBL Impact Learners Academic Achievement

SN	Items	VHE	HE	LE	VLE	Mean	Decision
1	The extent PBL enables me to actively engage with subject matter	37	83	30	20	2.81	Agreed
2	The degree to PBL enables me to apply what I learnt to real world	33	87	22	28	2.74	Agreed
3	The degree to which PBL enables me to apply what I learnt to real world	16	110	33	11	2.77	Agreed
4	The extent PBL makes me active compared to lecture method is	77	85	-	8	3.36	Agreed

SN	Items	VHE	HE	LE	VLE	Mean	Decision
5	My level of enthusiasm when engaged in PBL	45	77	48	-	2.98	Agreed
6	The degree of collaborative and team work that PBL offers	76	85	9	-	3.39	Agreed
7	The extent of understanding that PBL offers	66	83	21	-	3.26	Agreed
8	The degree that PBL prepares learners for future responsibilities	78	83	9	14	3.41	Agreed
9	The extent PBL allows me to explore subject matter	63	90	3	7	3.19	Agreed
	Aggregrate Mean					**3.10**	

Table 2, above, indicates an aggregate mean of 3.10, which is higher than the criterion mean of 2.50. All items mean were also above 2.50. This means learners hold the view that the project-based learning method has a high positive impact on their academic performance.

Table 3. Competencies Developed through Project-based Learning Method

S/N	Competencies	Agreed/Freq.	%	Disagreed/Freq.	%
1	Learners develop leadership skills during PBL	165	97	5	3
2	PBL encourages self-directed learning	159	93	11	7
3	Communication skills are improved through PBL activities	153	90	17	10
4	Collaboration skills are nurtured in PBL environment	145	85	25	15
5	Students develop problem-solving abilities through PBL	130	77	40	23
6	PBL enhances critical thinking skills	115	68	55	32
7	PBL fosters creativity and innovation	120	71	50	29
8	Students learn to manage their time effectively in PBL	109	64	61	36
9	PBL cultivates adaptability and resilience	100	59	70	41
10	PBL encourages initiative and entrepreneurial thinking	98	58	72	42

Table 3 showed that most respondents rated the following skills as important: leadership skills (165, 97%), self-directed learning (159, 93%), communication skills (153, 90%), collaboration skills (145, 85%), and problem-solving abilities (130, 77%). Students develop several important skills from problem-based learning in secondary schools. These skills include creativity and innovation (120, 71%), critical thinking

(115, 68%), time management (109, 64%), adaptability (100, 59%), and initiative (98, 58%).

Discussion

The findings on students' perception of project-based learning methods in comparison to lecture methods indicate that students perceived project-based learning methods as better than lecture methods. This suggests that education may start using more interactive methods that focus on students. This change could improve how students engage, think critically, and perform academically. To make this happen, teachers may need more training, resources might need to be redirected, and school policies may need to change to include project-based learning in lessons. The ultimate goal is to produce secondary school graduates who are more competent and motivated, ready for higher education and the modern workforce. This finding is similar to what Almulla (2020) discovered, showing that students preferred Project-Based Learning because it made them more engaged, connected to real-life situations, and helped them understand the material better. Chen et al. (2022) also found that students thought Project-Based Learning was more fun, motivating, and better for working with others than traditional teaching methods. Additionally, Martínez-Frutos (2020) reported that PBL led to more student engagement, satisfaction, and a feeling of better learning outcomes. It also aligns with Tsybenko et al. (2022); Chigbu et al. (2023), who opined that the need for a more result-oriented teaching method stems from the realization that the traditional method (lecture method) may not be adequately preparing students for the demands of the 21st-century workforce.

Research shows that using project-based learning methods greatly improves the academic performance of secondary school students. This suggests that schools should focus on adopting these methods, invest in them, train teachers, and possibly change educational policies to support and maintain these interactive and effective teaching approaches. This finding backs up earlier studies by Dai et al. (2023); Zhang & Ma (2023); Saavedra & Rapaport (2024), which found that students in project-based learning programs did better in school than those in regular classes. These studies concluded that the implementation of project-based learning methods has a positive impact on students' academic achievement in public secondary schools. Project-based learning was associated with improved learning outcomes, critical thinking skills, and student engagement.

The findings also suggest that students develop competencies such as leadership skills, self-directed learning, communication skills, collaboration skills, problem-solving abilities, creativity and innovation, critical thinking skills, time management, adaptability, and initiative abilities through the implementation of project-based learning methods in secondary schools. These findings point out that numerous benefits can be derived from the implementation of project-based learning methods, highlighting their potential to equip students with essential 21st-century competencies. These findings thus justify the integration of project-based learning into curricula to better prepare students for future academic and professional challenges.

The project-based learning has emerged as a prominent pedagogical method in public secondary schools, revolutionizing traditional classroom dynamics by offering students immersive and experiential learning opportunities. Owens & Hite (2022) found that students developed a wide range of competencies through project-based learning; Project-based learning in public secondary schools catalyzes the cultivation of collaboration and communication skills among students (Owens & Hite, 2022). PBL environments provide students with opportunities to work collaboratively in teams, fostering the development of interpersonal skills and effective communication strategies. Rooted in the principles of inquiry and hands-on exploration, PBL engages students in the investigation and resolution of authentic, real-world problems. They concluded that students not only deepen their understanding of academic subjects but also cultivate competencies crucial for success in an increasingly dynamic and interconnected world. Thus, teachers are to embrace PBL as a transformative tool for nurturing critical thinking, collaboration, and problem-solving skills, recognizing its capacity to prepare students for the multifaceted demands of the modern era.

4. CONCLUSION

This study has established numerous benefits associated with the implementation of project-based learning in secondary schools. Students find project-based learning to be more effective and engaging compared to traditional lecture methods. Implementing these methods has a strong positive impact on their academic performance. Beyond academics, project-based learning helps students develop a wide range of important skills. These include leadership, the ability to learn independently, effective communication, teamwork, problem-solving, creativity, critical thinking, time management, adaptability, and taking initiative. Overall, project-based learning is highly effective in both boosting students' academic achievement and equipping them with essential life skills.

As a suggestion, educators and school administrators should prioritize the adoption and integration of project-based learning methods into the curriculum, as students perceive these methods to be more effective than traditional lectures. Given the impact of project-based learning on the academic achievement of secondary school students, educational policymakers should support and fund training programs for teachers to effectively implement these methods in their classrooms. Additionally, to help students build important skills like leadership, self-learning, communication, teamwork, problem-solving, creativity, critical thinking, time management, adaptability, and initiative, schools should create a variety of projects that challenge them and encourage these abilities.

REFERENCES

Aifan, H. (2022). Implementing a project-based collaborative learning approach using PowerPoint to improve students' 21st-century skills. *E-Learning and Digital Media*, *19*(3), 258-273.

Almulla, M. A. (2020). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *Sage Open*, *10*(3), 2158244020938702.

Bielik, T., Finnie, K., Peek-Brown, D., Klager, C., Touitou, I., Schneider, B., & Krajcik, J. (2022). High school teachers' perspectives on shifting towards teaching NGSS-aligned project-based learning curricular units. *Journal of Science Teacher Education*, *33*(4), 413-434.

Chang, Y., Choi, J., & Şen-Akbulut, M. (2024). Undergraduate Students' Engagement in Project-Based Learning with an Authentic Context. *Education Sciences*, *14*(2), 168.

Chen, C. H., & Yang, Y. C. (2019). Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators. *Educational Research Review*, *26*, 71-81.

Chen, S. Y., Lai, C. F., Lai, Y. H., & Su, Y. S. (2022). Effect of project-based learning on development of students' creative thinking. *The International Journal of Electrical Engineering & Education*, *59*(3), 232-250.

Chigbu, B. I., Ngwevu, V., & Jojo, A. (2023). The effectiveness of innovative pedagogy in the industry 4.0: Educational ecosystem perspective. *Social Sciences & Humanities Open*, *7*(1), 100419.

Chimwayange, C. (2024). Promoting student engagement using project-based learning as service-based skills development. *International Journal of Technology and Design Education*, 1-18.

Chua, K. J., & Islam, M. R. (2021). The hybrid Project-Based Learning–Flipped Classroom: A design project module redesigned to foster learning and engagement. *International Journal of Mechanical Engineering Education*, *49*(4), 289-315.

Dai, Z., Sun, C., Zhao, L., & Zhu, X. (2023). The effect of smart classrooms on project-based learning: A study based on video interaction analysis. *Journal of Science Education and Technology*, *32*(6), 858-871.

Duke, N. K., Halvorsen, A. L., Strachan, S. L., Kim, J., & Konstantopoulos, S. (2021). Putting PjBL to the test: The impact of project-based learning on second graders' social studies and literacy learning and motivation in low-SES school settings. *American Educational Research Journal*, *58*(1), 160-200.

Feng, X., Sundman, J., Aarnio, H., Taka, M., Keskinen, M., & Varis, O. (2024). Towards transformative learning: students' disorienting dilemmas and coping strategies in interdisciplinary problem-based learning. *European Journal of Engineering Education*, 1-23.

Granado-Alcón, M. D. C., Gómez-Baya, D., Herrera-Gutiérrez, E., Vélez-Toral, M., Alonso-Martín, P., & Martínez-Frutos, M. T. (2020). Project-based learning and the acquisition of competencies and knowledge transfer in higher education. *Sustainability*, *12*(23), 10062.

Kim, K. J. (2020). Project-based learning approach to increase medical student empathy. *Medical education online*, *25*(1), 1742965.

He, P., Chen, I. C., Touitou, I., Bartz, K., Schneider, B., & Krajcik, J. (2023). Predicting student science achievement using post-unit assessment performances in a coherent high school chemistry project-based learning system. *Journal of Research in Science Teaching*, *60*(4), 724-760.

Martínez-Frutos, M. T. (2020). Project-based learning and the acquisition of competencies and knowledge transfer in higher education. *Sustainability*, *12*(23), 10062.

Hussein, B. (2021). Addressing collaboration challenges in project-based learning: The student's perspective. *Education Sciences*, *11*(8), 434.

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving schools*, *19*(3), 267-277.

Liu, H. H., Wang, Q., Su, Y. S., & Zhou, L. (2019). Effects of project-based learning on teachers' information teaching sustainability and ability. *Sustainability*, *11*(20), 5795.

Maros, M., Korenkova, M., Fila, M., Levicky, M., & Schoberova, M. (2023). Project-based learning and its effectiveness: evidence from Slovakia. *Interactive Learning Environments*, *31*(7), 4147-4155.

Martinez, C. (2022). Developing 21st century teaching skills: A case study of teaching and learning through project-based curriculum. *Cogent Education*, *9*(1), 2024936.

Martínez, S. S., Gila, D. M., Marchal, P. C., Kakko, A., Ortega, J. G., & García, J. G. (2020). Project based learning via solving a real business need by a multidisciplinary group of students. In *2020 XIV Technologies Applied to Electronics Teaching Conference (TAEE)* (pp. 1-6). IEEE.

Ngereja, B., Hussein, B., & Andersen, B. (2020). Does project-based learning (PBL) promote student learning? a performance evaluation. *Education Sciences*, *10*(11), 330.

Nguyen, V. A. (2017). A peer assessment approach to project based blended learning course in a Vietnamese higher education. *Education and Information Technologies*, *22*, 2141-2157.

Nguyen, H., Wu, L., Fischer, C., Washington, G., & Warschauer, M. (2020). Increasing success in college: Examining the impact of a project-based introductory engineering course. *Journal of Engineering Education*, *109*(3), 384-401.

Pan, A. J., Lai, C. F., & Kuo, H. C. (2023). Investigating the impact of a possibility-thinking integrated project-based learning history course on high school students' creativity, learning motivation, and history knowledge. *Thinking Skills and Creativity*, *47*, 101214.

Owens, A. D., & Hite, R. L. (2022). Enhancing student communication competencies in STEM using virtual global collaboration project based learning. *Research in Science & Technological Education*, *40*(1), 76-102.

Rehman, N., Huang, X., Mahmood, A., AlGerafi, M. A., & Javed, S. (2024). Project-based learning as a catalyst for 21st-Century skills and student engagement in the math classroom. *Heliyon*, *10*(23).

Rohm, A. J., Stefl, M., & Ward, N. (2021). Future proof and real-world ready: the role of live project-based learning in students' skill development. *Journal of Marketing Education*, *43*(2), 204-215.

Saavedra, A. R., & Rapaport, A. (2024). Key lessons from research about project-based teaching and learning. *Phi Delta Kappan*, *105*(5), 19-25.

Sasson, I., Yehuda, I., & Malkinson, N. (2018). Fostering the skills of critical thinking and question-posing in a project-based learning environment. *Thinking Skills and Creativity*, *29*, 203-212.

Smith, A., & Brown, K. (2021). Project-based learning: Enhancing student engagement and outcomes. *Journal of Educational Issues*, 7(1), 12-25.

Tirado-Morueta, R., Ceada-Garrido, Y., Barragán, A. J., Enrique, J. M., & Andujar, J. M. (2022). Factors explaining students' engagement and self-reported outcomes in a project-based learning case. *The Journal of Educational Research*, *115*(6), 333-348.

Tsybenko, E., Panferova, E., Volodina, M., & Vartanova, N. (2022). Digitalization of education and distance learning technologies: development trends. *International Scientific Conference on Agricultural Machinery Industry "Interagromash""* (pp. 2991-2999). Cham: Springer International Publishing.

Wang, X. M., Yu, X. H., Hwang, G. J., & Hu, Q. N. (2023). An online progressive peer assessment approach to project-based learning: A constructivist perspective. *Educational technology research and development*, *71*(5), 2073-2101.

Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M., & Loyens, S. M. (2024). The effects of problem-based, project-based, and case-based learning on students' motivation: A meta-analysis. *Educational Psychology Review*, *36*(1), 29.

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in psychology*, *14*, 1202728.

Zhang, W., Guan, Y., & Hu, Z. (2024). The efficacy of project-based learning in enhancing computational thinking among students: A meta-analysis of 31 experiments and quasi-experiments. *Education and Information Technologies*, 1-33.