THE EFFECTIVENESS OF IMPLEMENTING LEARNING PROJECT ON THE QUADRATIC FUNCTION IN HIGH SCHOOL

Vo Xuan Mai[1*] and Nguyen Thi Ngoc Tam[2]

[1]Faculty of Mathematics - Information Teacher Education,

School of Education, Dong Thap University, Cao Lanh 870000, Vietnam

[2]Hung Vuong High School, Binh Phuoc province, Vietnam

[*]Corresponding author: Vo Xuan Mai, Email: vxmai@dthu.edu.vn

Article history

Received: 25/3/2024; Received in revised form: 28/8/2024; Accepted: 04/9/2024

Abstract

Project-based learning is one of the modern teaching methods utilizing student group intelligence to perform the learning task designed by the teacher. Through this method, students can acquire knowledge and develop necessary skills in learning such as communication, collaboration, critical thinking, and problem-solving. This paper aimed to investigate the effectiveness of implementing a learning project on the topic of the quadratic function at high school. A quasi-experimental method was conducted in one month involving two classes of tenth-grade students, consisting of an experiment and a control class (conventional learning). Qualitative and quantitative data were collected through student activity observation sheets, mathematics pre-test and post-test. This study could provide an effect of utilizing project-based learning and opportunities to implement learning projects in high schools.

Keywords: *Learning project, project-based learning, project teaching method, process of learning project, quadratic function.*

DOI: https://doi.org/10.52714/dthu.13.7.2024.1341.

Cite: Vo, X. M., & Nguyen, T. N. T. (2024). The effectiveness of implementing learning project on the quadratic function in high school. *Dong Thap University Journal of Science, 13*(7), 89-98. https://doi.org/10.52714/dthu.13.7.2024.1341.

HIỆU QUẢ CỦA VIỆC THỰC HIỆN DỰ ÁN HỌC TẬP TRONG CHỦ ĐỀ HÀM SỐ BẬC HAI Ở TRƯỜNG TRUNG HỌC PHỔ THÔNG

Võ Xuân Mai[1*] và Nguyễn Thị Ngọc Tâm[2]

[1]Khoa Sư phạm Toán - Tin, Trường Sư phạm,

Trường Đại học Đồng Tháp, Việt Nam

[2]Trường Trung học phổ thông Hùng Vương, tỉnh Bình Phước, Việt Nam

[*]Tác giả liên hệ: Võ Xuân Mai, Email: vxmai@dthu.edu.vn

Lịch sử bài báo

Ngày nhận: 25/3/2024; Ngày nhận chỉnh sửa: 28/8/2024; Duyệt đăng: 04/9/2024

Tóm tắt

Dạy học dự án là một trong những phương pháp dạy học hiện đại nhằm phát huy trí tuệ của nhóm học sinh để thực hiện nhiệm vụ học tập do giáo viên thiết kế. Thông qua phương pháp này, học sinh có thể tiếp thu kiến thức và phát triển các kỹ năng cần thiết trong học tập như giao tiếp, hợp tác, tư duy phản biện và giải quyết vấn đề. Bài báo này nhằm khảo sát hiệu quả của việc triển khai dự án học tập chủ đề hàm số bậc hai ở trường trung học phổ thông. Phương pháp bán thực nghiệm được tiến hành trong một tháng với hai lớp học sinh lớp 10, gồm một lớp thực nghiệm và một lớp đối chứng (học thông thường). Đối với phân tích định tính và định lượng, dữ liệu được thu thập thông qua phiếu quan sát hoạt động của học sinh, phản hồi của học sinh và tiền nghiệm - hậu nghiệm với bài kiểm tra. Nghiên cứu này có thể mang lại hiệu quả của việc sử dụng phương pháp học tập dựa trên dự án và các cơ hội để thực hiện quá trình học tập theo dự án ở trường trung học.

Từ khóa: *Dự án học tập, dạy học theo dự án, hàm số bậc hai, phương pháp dạy học dự án, quy trình thực hiện dự án học tập.*

1. Introduction

Project-based learning (PBL) is a modern student-centered learning model in the teaching process. By this method, knowledge is acquired to create students' products through implementing tasks in learning projects and assigning them to groups, so students are encouraged to explore and practice to improve their knowledge and skills. However, this teaching method requires teachers to have the ability to design projects, organize group activities, and evaluate project products appropriately. Finding suitable math topics in high school to design learning projects for students is also a challenge for teachers. Therefore, designing and building learning projects on specific topics in math is a necessary task in mathematics teaching. The study aimed to investigate the effectiveness of implementing the learning project on quadratic function topics (Math grade 10) at high school through the process of the learning project. We address the following research questions:

1. What difference does a project-based learning make in students' understanding quadratic function topics at the high school level?

2. Can students' problem-solving skills be improved via a learning project?

2. Research results

2.1. Project-based learning

PBL is a learning model that involves students directly according to their experience and abilities in building a mathematics completion process through real-life projects. The term "project method" was developed by Dewey and Kilpatrick (Burlbaw, 2013). According to Kilpatrick, the key to the "project method" lay in its being "an activity undertaken by students that interested them. PBL is an essential strategy for creating independent thinkers and learners. Students solve real-world problems by designing their inquiries, planning their learning, organizing their research, and implementing multiple learning strategies (Bell, 2010). Moreover, students were able to revise their designs after consulting resources, which demonstrates a high level of motivation that is uncommon in traditional learning settings. Furthermore, these students demonstrated a solid grasp of the concepts and were able to perform well on traditional tests (Thomas, 2000).

Thus, PBL and other instructional approaches that emphasize deeper learning and the development of skills needed for success in college, career, and civic life have become increasingly popular (Huberman et al., 2014). PBL usually require students to participate willingly in the meaningful learning activities proposed, mostly teamwork. In PBL environments, students learn primarily by constructing knowledge and making meaning through iterative processes of questioning, active learning, sharing, and reflection (English & Kitsantas, 2013). It emphasizes educational opportunities that are interdisciplinary, student-centered, collaborative, and integrated with real-world issues and practices.

2.2. Learning project

A learning project is a project which learners actively perform complex learning tasks that combine theory and practice; combine knowledge, skills, practical experience in many fields to create recommendable products with the guidance of a teacher. The PBL design principles are intended to clarify the meaning of PBL and help teachers identify the difference between project-based learning and simply "doing projects". As a result, PBL design principles do not communicate specific disciplinary concepts and practices. However, some PBL scholars set guidelines for the types of questions and topics that students should encounter.

Driving questions are at the core of the project-based science design principles (Krajcik & Shin, 2014). Krajcik and Naaman (2006) explained: "a driving question is a well-designed question that students and teachers elaborate, explore, and answer throughout a project". Krajcik and Mamlok-Naaman (2006), Krajcik and Shin (2014) provided the following five criteria for high-quality driving questions: (1) feasible, (2) worthwhile, (3) contextualized, (4) meaningful, and (5) ethical. For example, a driving question from project-based learning in teaching Mathematics at high school is "How is knowledge of functions and their graphs applied to solving real-world problems?".

2.3. Students' problem-solving and collaboration capacity in project-based learning

PBL has been argued to result in high levels of student engagement because of the freedom and challenges students experience in solving the problems that arise in designing and building their

projects (Wurdinger et al., 2007), as well as in designed projects' affective, ethical, and aesthetic dimensions in addition to cognitive challenges (Wrigley, 2007). Students collaborate with others in their classroom and their teacher to ask questions, write explanations, make sense of information, discuss data, solve problems, and present findings (Krajcik & Blumenfeld, 2006). In another publication (Patton, 2012), the significance of student collaboration, reflection, redrafting, and presentations is emphasized from the result of Thomas (2000) with five essential characteristics of projects: (1) Centrality, (2) Driving question, (3) Constructive investigations, (4) Autonomy, and (5) Realism. Students learn to be self-reliant through goal-setting, planning, and organization; they develop collaboration skills through social learning and become intrinsically motivated by being encouraged to exercise an element of choice while learning at their level (Bell, 2010).

2.4. The process of implementing learning project

Some previous studies have proposed the process of implementing learning projects. Bell (2010) emphasized the process of implementing a PBL includes the following steps: Step 1: Start with the essential question, Step 2: Design a plan for the project, Step 3: Create a schedule, Step 4: Monitor the students and the progress of the project, Step 5: Assess the outcome, Step 6: Evaluate the experience. According to Vu and Nguyen (2019), the process of building a learning project is determined: (1) Determine the name of the learning project, (2) Orient reference sources, (3) Plan activities, (4) Choose appropriate learning methods, (5) Evaluate students' development.

On the basis of studying the process of building a learning project, we propose the process of implementing a teaching project related to real-life in teaching mathematics as follows:

• *Stage 1: Building a learning project*

- Ideas to build a learning project: The teacher proposes an idea of the project topic from a problem situation or learning task to be solved.

- Proposing project names: Teachers introduce some project names on topics for students to choose from or students and groups of students propose project names.

- Selection of project name: Students discuss and conclude that the learning project name, thereby agreeing to choose the project name on the basis of the teacher's orientation on ensuring the suitability of the program's objectives, contents and conditions.

- Define learning project goals.

- Assignment of project content:

+ The teacher divides the class into groups in accordance with the tasks of the project, in accordance with the students' ability.

+ The teacher anticipates the content of the project, builds a set of suggested questions (including theoretical questions and practical questions or practical tasks)

+ Assign project content to each group. Each group performs the following tasks:

General task: each group read references related to the topic and project name, answer theoretical questions, systematize knowledge and design into mind maps or tables.

Separate tasks: Each group performing practical tasks is divided to perform 2 tasks: Applying math knowledge of the topic studied in the set of theoretical questions to solve real-world problems, assumed by the teacher (assigned corresponding practical tasks) and research to state 2 other real-life problems that the group has collected and solved.

- The teacher stated the project implementation time: 4 periods (1 theory period, 2 exercise periods, 1 practical period) and conducted in two weeks of the academic year.

- Groups receive tasks, select group leaders, and assign tasks to group members.

- Groups collect information from documentary sources, conduct field surveys, compile documents presenting relevant issues.

- Prepare draft documents.

- Teams carry out assigned work.

- Report to the class about the group's products.

- Complete the learning project, return the project product.

• *Stage 2: Planning the implementation of the learning project*

- The group of students answered theoretical

questions and practical questions, researched and raised two other practical problems related to the content of the group's assigned learning project that the group had solved.

- The group of students assigns individual tasks with specific detailed learning activities about work content, references, methods, tools, means of implementation, completion time of individuals.

- Groups of students discuss and exchange to summarize the answers, the results of completing individual tasks, edit the results and write the content of the product report.

- Based on the project goals and time budget for implementing the joint learning project, the teacher supervises, comments, and edits the plans of the groups to help students follow the right direction.

• *Stage 3: Presentation of the product of the learning and assessment project*

- Students report the results of the learning project in the classroom (theory and practical tasks and 2 additional research proposals of the group).

- Students discuss to other groups of students and the teacher.

- Students self-assess and comment on the results achieved by the group and its members.

- Teacher evaluates the process of implementing the learning project of each group.

2.5. Implementing the learning project on the quadratic function topic (Math grade 10)

2.5.1. Objectives of the quadratic function in Math grade 10

Under the General Education Program in Mathematics (Ministry of Education and Training, 2018), the requirements to meet the topic of quadratic functions include: Establishing a table of values of quadratic functions; Draw a parabola which is a graph of a quadratic function; Recognize the basic properties of parabola such as vertex and axis of symmetry; Recognize and explain the properties of quadratic functions through graphs; Apply knowledge of quadratic functions and graphs to solve real problems (for example: determining the height of bridges, parabola-shaped gates,...).

2.5.2. Implementing the learning project on the topic of the quadratic function

Based on the proposed process, we apply it to carry out a learning project on the topic of quadratic functions. The results of the project implementation process are recorded through the following main stages:

• *Stage 1- Building a learning project:*

The learning projects' name: *The application of the quadratic function in solving real-life problems*. The tasks of the project: Set of suggested questions in this topic as follows:

- Driving question: *What problems can the application of functions and graphs solve in real-life?*

- Theoretical questions: *What is a quadratic function? What is a definite set, a set of values, and a graph of a quadratic function? Variation of quadratic function? What is the quadratic function like? What are the characteristics of the graph?*

- Some real-world problems: *How to apply knowledge of quadratic functions to solve real-world problems?* Perform the following tasks:

Task 1: The Arch Gate in the US city of St Louis is shaped like a parabola. The distance between the legs of the gong is 162m. On the gate wall, at a height of 43m above the ground, a rope was dropped to the ground. The ground position of the end of this rope is 10m from the foot of the gate. Calculate the height of the gate (Figure 1).

Task 2: In the Angry bird game, there is a bird from 5m (meter) above the ground from the left bank. The player scores when the bird falls on the right or over the ground 6m away. Know that the land mine is 2m high and the bird can fly as high as 2m at a position 4m from the starting shore. Does the player to score points or not? (Figure 2).

Task 3: Let's pose a practical problem that applies knowledge of quadratic functions to solve the problem

• *Stage 2: Planning the implementation of the learning project*

- The group of students answered theoretical questions and practical questions, researched and raised two other practical problems related to the content of the group's assigned learning project that the group had solved. Solutions from student groups:

Task 1: $A(0;0)$, $B(162;0)$, $C(10;43)$ (Figure 1).

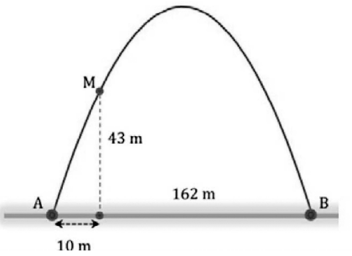

Figure 1

Equation of parabola: $y = ax^2 + bx + c$ (1). We have:

$$\begin{cases} c = 0 \\ 162^2 a + 162b + c = 0 \\ 100a + 10b + c = 43 \end{cases} \Leftrightarrow \begin{cases} a = -\dfrac{43}{152} \\ b = \dfrac{3483}{76} \\ c = 0 \end{cases}$$

$$\Rightarrow y = -\frac{43}{152}x^2 + \frac{3483}{76}x$$

So the height of the gate: $x = -\dfrac{b}{2a} = 81 \Rightarrow h = 185,6m$.

Task 2: A is the bird's starting point, B is the point of maximum altitude (the top of the parabola), C is the land mine, and D is the bird's grounding point. So A(0;5), B(4;7) (Figure 2).

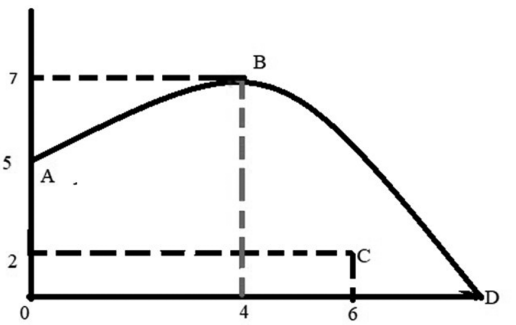

Figure 2

We have:

$$\begin{cases} c = 5 \\ 16a + 4b + c = 7 \\ -\dfrac{b}{2a} = 4 \end{cases} \Leftrightarrow \begin{cases} a = -\dfrac{1}{8} \\ b = 1 \\ c = 5 \end{cases}$$

$\Rightarrow y = -\dfrac{1}{8}x^2 + x + 5$. Therefore, with $x = 6$

$\Rightarrow y = 6,5 > 2$, with $y = 0 \Rightarrow x = 11,48 > 6$. So the player has a score.

Task 3: Some problems that are proposed from the groups' results.

Problem 1: The supporting transmission wire on the suspension bridge has the shape of Parabola ACB as shown. The beginning and end of the wire are attached to points A and B on each axis AA' and BB' at a height of 30 meters. The length of section A'B' on the bridge foundation is 200 meters. The shortest height of the transmission line on the bridge is OC = 5 meters. Let Q', P', H', C', I', J', K' be the points dividing segment A'B' into equal parts. The vertical bars connecting the bridge foundation with the bottom of transmission lines QQ', PP', HH', CC', II', JJ', KK' are called suspension cables. Calculate the total length of the suspension cables? (Figure 3).

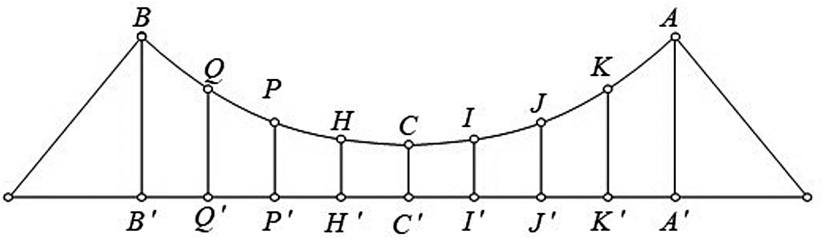

Figure 3

Problem 2: A rescue helicopter is preparing to spray water on a forest fire from the air. The height h (feet) of water above the ground calculated according to time t (s) from the time the aircraft ejected is determined by the formula $h(t) = -16t^2 - 2t + 500$. The horizontal distance from the fire point to the aircraft is x = 91.t (feet), t (s) is also the time since the aircraft sprayed water. So, what is the horizontal distance from the fire to the plane? (Figure 4).

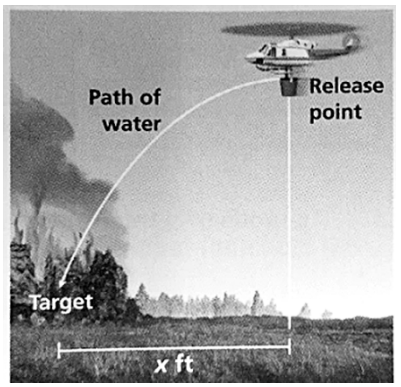

Figure 4

Problem 3: The height h (feet) from the bridge deck of the Golden Gate Bridge is determined by the formula $h(x) = \frac{1}{9000}x^2 - \frac{7}{15}x + 500$, in which x (feet) is the distance from the left pillar. Calculate the height of the bridge piers (Figure 5).

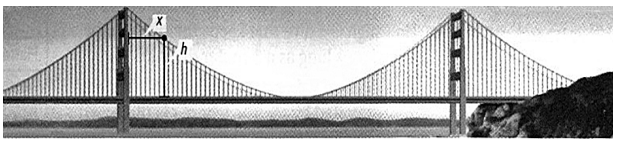

Figure 5

• *Stage 3: Presentation of the product of the learning and assessment project*

Students report the results of the learning project in the classroom and discuss on the results. Finally, the teacher evaluates the process of implementing the learning project of each group.

Figure 6. Students' collaboration and presentation

2.6. Method

2.6.1. Research design

This study was a quasi-experimental study using a pretest-posttest control group design. The experimental class was taught using a project-based learning method, while the control class was taught using a conventional learning method. The two selected classes have equivalent levels of math ability based on the average Math test scores of semester 1 before conducting project-based learning. The experimental class was divided into small groups, in which each group was heterogeneous (including students with low, average, and high math ability).

2.6.2. Research sample

Research participants came from two classes from a high school (Hung Vuong High School) in Binh Phuoc, Vietnam, selected with similar math proficiency levels. The participants were divided into two groups: experimental and control. The control class consisted of 42 students (Class 10D4) and the experimental class consisted of 42 students (Class 10D3). All students were in grade ten and aged between 15 - 16 years old. There was no difference in variance between the two groups with results in Mathematics semester 1.

The research instruments were developed a student observation activity, pre-test, and post-tests. The observation sheet and response questionnaire were adapted from previous research. The pre-test and post-test were developed by the researchers. The post-test comprised eight questions, each of which consists of fifth essay items. All the items were then tested to examine the validity and reliability to a class that was different from the control and experiment classes. The collection of experimental results is shown in Table 1.

Table 1. The Collection of Experimental Results

Group	Pre-test	Treatment	Post-test
Experimental class (use PBL)	Average result in Mathematics semester 1	The lessons with applying the process of implementing learning project	Test results after the experiment Student opinion survey
Control class (regular learning)	Average result in Mathematics semester 1	No treatment	Test results after the experiment

3. Result

Descriptive statistics in Table 2 show that the mean values of the experimental and control classes were 8.00 and 7.02, respectively, reflecting significant differences. The independent t-test results show the Sig value. (2-tailed) equals 0.001 < 0.05, so the difference in mean score between the two classes was statistically significant. Accordingly, the null hypothesis was rejected, and the alternative hypothesis was accepted.

Table 2. Results after treatment

Class	N		Mean	Std. Deviation	Std. Error Mean
Experimental class	42		8.00	0.68	0.016
Control class	42		7.02	1.35	0.208
t-test for Equality of Means					
	t	**Df**	**Sig.(2-tailed)**	**Mean Difference**	**Std. Error Difference**
Equal variances assumed	27.222	56.578	0.001	0.98	0.192

4. Discussion

PBL allows students to apply mathematical concepts and skills to real-world problems or scenarios. This approach helps them understand the practical applications of mathematics, making the subject more engaging and meaningful. Responses from participating students show that students engage in PBL when they interact in school as well as in real life. Understanding the experience, reflecting, transforming, and problem-solving is a collaborative process that substantially changes depending on the learning environment. Projects often involve open-ended problems that require students to analyze, strategize, and devise solutions. This process enhances their problem-solving abilities, critical thinking, and decision-making skills, which are essential in mathematics. As a result, the skills acquired through participation in the learning project process are equally diverse, encompassing knowledge and abilities relevant to a specific subject.

PBL typically involves group work where students collaborate, share ideas, and learn from one another. This approach fosters teamwork, communication, and interpersonal skills, which are valuable for their future academic and professional endeavors. The implementation of a learning project related to real-life problems in teaching mathematics

brings excitement, stimulates the development of student proficiency in mathematics, and provides a working environment among group members in a comfortable and free classroom. Students actively participate to contribute ideas in speeches and support each other to complete assigned tasks, and students' ability to express themselves in presentations is increasingly improved. Students are confident in finding ways to solve problems when encountering unfamiliar situations in practice.

Through these projects, students can learn mathematical knowledge not only in textbooks but also through books and the internet, an essential academic skill that they must gain, such as the skills of using technology, solving problems independently, collaborative work, critical thinking, and finding resources. PBL often involves research, data collection, as well as presenting findings or solutions. This process helps students develop valuable research, organizational, and presentation skills.

5. Conclusion

PBL is an innovative approach to learning for the development of students' competence. By actively engaging with mathematical concepts through projects, students develop a deeper understanding of the subject matter and construct their knowledge. They have the opportunity to explore, apply, and solve the problems, leading to more meaningful learning. This study investigated the effect of implementing a learning project on the quadratic function when solving real-life problems. The results showed the significant effectiveness of implementing a learning project, and the PBL approach needs further investigation in mathematics teaching in high school.

References

Bell, S. (2010). Project-Based Learning for the 21st Century Skills for the future, The clearing house: A journal of educational strategies. *Issues and Ideas, 83*(2), 39-43 https://doi.org/10.1080/00098650903505415.

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3&4), 369-398.

Burlbaw, L. M., Ortwein, M. J., & Williams, J. K. (2013). The project method in historical context. *In STEM Project-Based Learning* (pp. 7-14). Brill.

Campbell, S. A. (2012). The phenomenological study of ESL students in a project-based learning environment. *International Journal of Interdisciplinary Social Sciences, 6*(11), 139-152.

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem and project-based learning. *Interdisciplinary Journal of Problem-Based Learning, 7*(2), 128-150.

Green, A. M. (1998). *Project-based-learning: moving students toward meaningful learning*. ERIC Data base, ED422466.

Huberman, M., Bitter, C., Anthony, J., & O'Day, J. (2014). *The shape of deeper learning: Strategies, structures, and cultures in deeper learning network high schools*. Washington, DC: American Institutes for Research.

Krajcik, J. S., & Blumenfeld, P. (2006). Project-based learning. In Sawyer, R. K. (Ed.), *The Cambridge handbook of the learning sciences*. New York: Cambridge.

Krajcik, J. S., & Mamlok-Naaman, R. (2006). Using driving questions to motivate and sustain student interest in learning science. In K. Tobin (Ed.), *Teaching and learning science: A handbook*. 317-327, Westport, CT: Praeger.

Krajcik, J. S., & Shin, N. (2014). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences*. 275-297, New York, NY: Cambridge University Press.

Patton M. (2012). Work that matters: The teacher's guide to project-based learning. London: Paul Hamlyn Foundation.

Siswono, T. Y. E., Hartono, S., & Kohar, A. W. (2018). Effectiveness of Project Based Learning in Statistics for Lower Secondary Schools. *Eurasian Journal of Educational Research, 75*, 197-212.

Thomas, J. W. (2000). *A review of research on project-based learning*. California: The Autodesk Foundation.

Thuy, V. T. T., & Hong, N. V. (2019). The process of building a learning project in the direction of developing scientific research competence for high school students. *Journal of Education Vietnam, 464*, 60-64.

Wrigley, T. (2007). Projects, stories and challenges: More open architectures for school learning. In Bell S., Harkness S., White G. (Eds.), *Storyline past, present and future* (pp. 166-181). Glasgow, Scotland: University of Strathclyde.

Wurdinger S., Haar, J., Hugg, R., & Bezon, J. (2007). A qualitative study using project-based learning in a mainstream middle school. *Improving Schools, 10*, 150-161.