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Project-Based Teaching in Organic Chemistry through Blended Learning Model to Develop Self-Study Capacity of High School Students in Vietnam

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Abstract: Developing students' self-study capacity is an urgent task of high schools in the current educational renovation period in Vietnam. This article presents research findings on developing self-study capacity for students through building and organizing teaching activities of 11th-grade organic chemistry project topics according to the blended learning model. The pedagogical experiment was conducted at three high schools in the north, central, and south regions of Vietnam with 125 students. The data obtained from the teacher's assessment and the students' self-assessment showed obvious development of students' self-study capacity in experimental classes.

Keywords: blended learning; self-study capacity; project-based teaching; organic chemistry; high school

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1. Introduction

The essence of learning is self-study; it is agreed that self-study capacity is an essential capacity that determines the learning outcomes of learners and is the foundation for lifelong self-study. In response to the development and integration requirements in the age of Industrial Revolution 4.0 and the trend of educational development globally, education in Vietnam is entering a period of fundamental and comprehensive innovation. Educational goals are changing the focus from equipping learners with knowledge to developing learners' qualities and capacities. The new general education program [1] has identified self-study capacity, structured in autonomy and self-study capacity, as one of the core competencies that need to be formed and developed for students in Vietnamese high schools.

Blended learning is a teaching model that combines online teaching methods and face-to-face teaching methods with the right sequence and ratio to bring about effectiveness in education. Blended learning combines the best online and face-to-face teaching elements, which will become the mainstream teaching model in the future [2]. Blended learning is also a new trend in educational science research. Blended learning could be defined with three groups: (1) combination of teaching methods (or teaching means); (2) combination of teaching methods; (3) combination of online teaching and face-to-face instruction [3]. Blended learning is a formal educational program in which learners learn at least in part through content and instruction provided online with some control element over time, place, method, and pace and have at least part of traditional classroom learning supervised away from home [4]. Therefore, blended learning is a teaching model with a unified and complementary combination of online teaching methods over the internet and face-to-face in the classroom to create good conditions for students to achieve the learning goals when occupying the same content in the learning program. Combining the two methods in different sequences and ratios reflects the regular internal relationship between the objectives–content–teaching methods and will create different blended learning models. There have been many blended learning models launched, notably four models: (1) rotation model (including station-rotation model, lab-rotation model, flipped classroom model, and individual-rotation model); (2) flex model; (3) A La Carte model; and (4) enriched virtual model [5]. Blended learning processes are also proposed by many authors [6–8]. In a blended learning process, five elements are emphasized: (1) live event; (2) self-paced learning; (3) collaboration; (4) assessment; (5) performance support materials [9]. In the world, there have been many authors interested in researching blended learning; the effectiveness of blended learning in teaching for high school students is indicated in several studies [10–23]. Especially, the positive impact of the flipped classroom (one of the models of blended learning) on the attitude and study results of students was demonstrated in several research findings [24–27]; Hadisaputra et al. [28] showed the effectiveness of developing students' critical thinking skills through teaching chemistry according to the blended learning model. In Vietnam, applying the blended learning model in general education initially received attention from the conference "Application of information technology in blended learning to meet the requirements of the new general education program" organized by the Ministry of Education and Training in 2015, and many authors have been applying the blended learning model in teaching several subjects at high schools. However, studies on applying blended learning in teaching chemistry to develop students' self-study capacity in Vietnam are limited and still a new research field. On the other hand, through a survey of teachers and students in Vietnamese high schools, it is agreed that developing students' self-study capacity is necessary, and those high schools that already have enough facilities and primary conditions can organize teaching activities according to the blended learning model [29].

Project learning is an active, student-centered teaching method that encourages students to work collaboratively in groups on real-world questions or challenges to promote the acquisition of critical thinking skills, higher-order thinking, in which the teacher acts as a facilitator of learning [30]. Students learn self-control through goal setting, planning, and execution, develop collaborative skills through social learning, and are truly motivated by being encouraged to perform their chosen task at school at the individual level [31]. The effectiveness of this method in chemistry has been discussed in some research [32,33]. In Vietnam, the Organic Chemistry section in the grade 11 textbook of the Chemistry curriculum provides students with important theoretical foundations and initial application in the study of homologous sequences of monomeric organic compounds. The information presented in the textbook is quite extensive and difficult to remember, and thus it requires teachers to organize self-study activities for students regularly. The Organic Chemistry section of grade 11 has many contents related to real life. Teachers also have many opportunities to organize students' self-study by participating in learning projects. There have been many domestic authors studying the application of project-based teaching in Chemistry. However, the research studies have not emphasized the role of the combination of online teaching activities with face-to-face activities in organizing project-based teaching and the advantages of this in developing students' self-study capacity.

Therefore, in this research, the problem of building and organizing teaching activities of 11th-grade organic chemistry project topics according to the blended learning model was clearly stated in accordance with teaching conditions in Vietnamese high school education in order to develop students' self-study capacity and demonstrate the effectiveness of this proposal through analysis of experimental data.

2. Methods

2.1. Objective

The research aimed to develop students' self-study ability by applying project teaching according to the blended learning model in teaching Grade 11 Organic Chemistry.

The identified research tasks include:

- Building the structure of self-study capacity of high school students.

- Developing project topics for organic chemistry class 11.
- Developing a project teaching process according to the blended learning model and designing an illustrative teaching plan to develop students' self-study ability.
- Pedagogical experiment to evaluate the feasibility and effectiveness of impact measures in developing students' self-study capacity.

2.2. Research Design

2.2.1. The Basis of Research Design

The research process was designed based on the following theory:

The basis of research on building the structure of self-study capacity of high school students

According to Nguyen Canh Toan [34], self-study capacity is an individual attribute that allows students to actively use existing resources (knowledge, skills, motivation, emotions) to achieve the work of creating and implementing learning plans, evaluating results, and making adjustments to achieve defined learning goals with the support of teachers and in cooperation with other classmates. Based on the manifestations of self-study capacity given in the general education program of Vietnam in 2018 [1], the structure of self-study capacity is established, including 4 component competencies and 10 manifestations [35]. Component and manifestation competencies include:

- The capacity to identify learning goals has two manifestations: set learning goals; identify what is known relevant to the learning objective.
- The capacity to develop a learning plan has two manifestations: determine the means and methods to perform the learning tasks, schedule the time, and expect the results to be achieved.
- The capacity to implement the learning plan has 4 manifestations: collect information, process information, and solve learning problems; cooperate with teachers and classmates; present and defend learning results.
- The capacity to evaluate and adjust learning has two manifestations: assess learning results (analysis, comparison, contrast to determine the level of achievement of set learning goals); learn from experience and adjust learning (recognize limitations and errors and adjust to make the learning process more and more effective).

The basis of building a system of project topics for organic chemistry at high schools in the direction of developing students' self-study capacity

Developing project topics is a key factor in organizing project-based teaching and is essential for teachers to orient and guide students to implement projects. The construction of project themes was based on the following six principles:

Principle 1: The project topic must adhere to the content of knowledge and the teaching objectives of the 11th-grade Organic Chemistry lesson, focusing on creating opportunities for students to apply and expand practical knowledge related to the lesson content.

Principle 2: Project topics must associate real life with social issues close to students' daily activities in the locality, with profound social significance.

Principle 3: The project topic must be closely related to developing students' capacity, especially self-study capacity. The project themes should contain complex practical problems, requiring students to integrate subject knowledge with social understanding to solve and regularly perform self-study tasks in coordination with classmates, thereby developing students' competencies, especially self-study capacity and social activity capacity, and forming a positive attitude in community activities.

Principle 4: Project topics must be appropriate to the cognitive level and attract students' interest and attention.

Principle 5: Learning project topics should have rich sources of materials and be suitable to the facilities and needs of the school and society, creating conditions for students to exploit, use them, and create meaningful products.

Principle 6: Project themes should support information technology integration. To solve the problems of the project topic, students should know how to apply information technology to a certain extent.

The basis of building a project-based teaching process according to the blended learning model and designing specific lesson plans to develop students' self-study capacity

A project-based teaching process according to the blended learning model using Microsoft Teams was constructed and specific lesson plans were designed based on the following foundation: (1) project-based teaching process; (2) characteristics and ingredients of blended learning model; (3) requirements for the development of self-study capacity and expression of self-study capacity of high school students; (4) the facilities of the high school; (5) features of Microsoft Teams.

2.2.2. Research Design

The research process was conducted through the following stages:

Stage 1: Research on building the structure of self-study capacity of high school students.

Stage 2: Building a system of project topics for 11th-grade organic chemistry at high schools in the direction of developing students' self-study capacity.

The construction of project themes is carried out through the following steps:

- *Step 1: Proposing topic ideas:* Derived from the analysis of the structure, content of lessons in the program, and relevant practical knowledge to determine the names and objectives for the project topics.
- *Step 2: Identify the problems to be solved of the project topic: Identify the main contents, problems/questions that students need to solve in implementing the project according to* their level and actual teaching conditions.
- *Step 3: Build information sources and instructions:* Search for informational sites (books, websites) and design guidelines for students that correspond to the problems to be solved on the project topic.
- *Step 4: Seek expert advice:* Conduct consultation with experts who are chemistry lecturers at pedagogical universities and experienced chemistry teachers at high schools. Then edit the following comments.
- *Step 5: Test and perfect edit:* Conduct pilot teaching at high schools, get feedback from teachers and students in the test to continue to edit and perfect the project topics.

At the end of the topic development process, comments from 45 experts were collected to confirm the practicality, accuracy and science, relevance, and feasibility of the established topics.

Stage 3: Building a project-based teaching process according to the blended learning model and designing specific lesson plans to develop students' self-study capacity.

Stage 4: Pedagogical experiment and experimental data processing.

2.3. Participants

Forty-five experts who are lecturers at 3 universities (Hanoi Pedagogical University 2, Hanoi National University of Education, and Ho Chi Minh City University of Education) and Chemistry teachers at 20 high schools in the north, central, and south regions evaluated the practicality, accuracy and science, relevance, and feasibility of 30 obtained projects.

Pedagogical experiments were conducted in 3 classes of grade 11 (125 students), including 11A2 (41 students) of high school Yen Dung No. 2 (Bac Giang Province), class 11B7 (40 students) of Kon Tum High School (Kon Tum Province), and class 11/2 (44 students) of Go Cong High School (Tien Giang Province), to evaluate the feasibility and effectiveness of the proposed teaching process. Students of experimental classes took turns to participate in 3 project groups on alkanes, alcohols, and carboxylic acids.

2.4. Instruments

In order to be consistent with the research content, the researchers selected a pre- and post-impact test design for the only group. The development of self-study capacity of students in the experimental class was assessed by the teacher and the students' self-assessment through the use of a toolkit including a criterion-based assessment sheet using criteria listed in Table S1 (see in Supplementary), rubrics, KWL diagrams, project product evaluation sheets, project performance evaluation sheets, and special tests [36].

2.5. Data Analysis

Experimental data were processed and analyzed using SPSS software to conclude the effectiveness of project-based teaching organization according to the blended learning model in developing students' self-study capacity.

3. Results

3.1. Project Topic System for Organic Chemistry Grade 11

In Vietnam, the Organic Chemistry section in grade 11 contains knowledge related to real life. Therefore, this knowledge is suitable for organizing students' self-study using project-based teaching. For each project topic, the research problems need to be clearly defined since these problems are the project's specific goals, the content that students need to achieve when implementing the project. In addition, these problems are the basis for students to identify tasks and plan to implement the project in the next stage. Therefore, teachers need to build research problems of each proposed project topic to be ready to provide suggestions, guide students, or organize for students to propose problems that are suitable for their conditions, specificity, and culture of each region. By applying the principles and processes above, a system of 30 project topics related to hydrocarbon and hydrocarbon derivatives knowledge was built with research problems (research questions) presented in Tables 1 and 2.

Table 1. Project topic system of the hydrocarbon part in high school.

Research Problems
Petroleum—a non-renewable resource
1. What is the state, physical properties, and chemical composition of petroleum? How are they formed?
2. How is petroleum extracted and processed? What is the environmental impact of extraction and use? How to minimize those effects?
3. What are the applications of petroleum products in industry and life? Why?
4. How to use gasoline fuels safely and efficiently?
Natural gas and petroleum gas
1. What is the composition of natural gas, petroleum gas? How are they formed?
2. Where are natural gas and petroleum gas distributed in the territory of Vietnam, and what are their reserve and quality?
3. How to exploit, process, and apply natural gas?
4. How to use gas fuels safely, economically, and effectively?
Oil spill incident at sea
1. What are oil and gas exploration and production like?
2. What is the cause of the oil spill? List some oil spill incidents that have occurred?
3. What harm does the oil spill cause to the environment?
4. How to respond and handle oil spills? How does Vietnamese law regulate oil spill response?
Civil gas cylinders and how to use them safely and effectively
1. What is the composition of gas?
2. How are civil gas cylinders manufactured?
3. How to detect a leaky gas cylinder and how to deal with someone choking on gas?
4. How to use gas cylinders at home safely and economically? What should fire equipment be in the home?
Biogas—green fuel
1. How does waste from livestock production households cause environmental pollution? How are such wastes disposed of locally?
2. What is the composition of biogas?
3. Structure and operation of biogas digesters?
4. What is biogas used for? What are the benefits of biogas for farmers and environmental protection?
Potential and environmental impacts of methane
1. Where does methane come from in nature? What applications does methane have in life and production?
2. What impact does methane cause on the environment and climate change? What effects does this change have on human life?
3. How to minimize the source of methane generation and its impact on the environment?
4. Are there any local activities that increase or decrease natural methane sources?

Table 1. *Cont.*

Research Problems
Paraffin—scented candles
1. What types of candles are used in life? What is a scented candle? What are the uses of scented candles? 2. What are the ingredients, tools, and processes for making scented candles? 3. Make scented candles and themed decorations. How to make scented candles with different flame colors? 4. What should be paid attention to use scented candles safely and effectively? 5. Besides scented candles, what other creative products can be created from paraffin?
Safe fruit vinegar
1. Why must ripen fruit? Are there ways to ripen the fruit? What is the basis of that approach? 2. Which vinegar method is safe? How does vinegar have the potential to affect the health of vinegar people and consumers? Why? 3. Make a safe way to make fruit vinegar at home. 4. How to identify natural ripe fruit and fruit juice pressed with medicinal vinegar on the market? 5. When to slow down the ripening of fruit? How to slow down the ripening of fruit?
Natural rubber
1. Where does natural rubber come from? What are the composition and chemical structures of natural rubber? 2. Rubber trees are mainly distributed in which locality of our country? What are the process of exploitation and preliminary processing of natural rubber? 3. What are the properties and applications of natural rubber? 4. How to recognize and preserve natural rubber products?
Terpene—flavor for life
1. What are terpenes? Are terpenes a polymerization product of isoprene? 2. in what sources in nature are terpenes found? How are they mined? 3. What are the structures and names of terpenes and derivatives found in some essential oils and natural pigments? 4. What is the role of terpenes and derivatives in the cosmetic, food, and pharmaceutical industries?
Production of lemon and grapefruit essential oils
1. What are the chemical compositions of essential oils of lemon, grapefruit? In which part of lemons and grapefruits are essential oils abundant? 2. What are lemon and grapefruit essential oils used for in life? 3. What are the methods, tools, and processes for producing lemon and grapefruit essential oils? What is the role of tools? What tools are easy to find around us? 4. Refining lemon and grapefruit essential oils. How to present and introduce lemon and grapefruit essential oils? 5. What measures are there to scale up production? How to design a simple essential oil lamp?

Table 2. Project topic system for hydrocarbon derivatives in high school.

Research Problems
Phenol and glue
1. Are there different types of glue used in today's life? What type of glue is made from phenol? 2. What is the process of producing glues from phenol and compounds? 3. How is wood glue used in the woodworking industry? 4. How do the production process and use of glue in furniture production affect the environment? How to limit those effects?
Practice application of ancol etylic
1. How is Ethyl alcohol applied in the fields (food, cosmetics, pharmaceutical-medical, fuel . . .) like? 2. For what chemical production processes are Ethyl alcohol used as a raw material? 3. What are the applications of ethyl alcohol based on its properties?
Situation and solutions to the problem of alcohol abuse
1. What is the status of alcohol use in Vietnam and in the residential areas where you live? 2. How is the process of absorbing and metabolizing alcohol in the body? What are the effects of alcohol abuse on human health? How to cure drunkenness? 3. What are the consequences of alcohol abuse to society? How does the traffic law regulate alcohol concentration while driving? 4. What recommendations should be made for people to use alcohol safely and rationally?
Fake alcohol
1. What is fake alcohol? How is fake alcohol made? 2. What harms does fake alcohol cause to human health? What ingredients cause poisoning when drinking fake alcohol? 3. How to distinguish between fake alcohol and real alcohol like? 4. How to handle when someone mistakenly drinks fake alcohol?
Biofuel E5
1. What is biofuel E5? What is the composition of biofuel E5? Why should we use ethanol but not other alcohols to mix in gasoline? 2. What are the advantages and disadvantages of biofuel E5? Why is biofuel E5 rated as an environmentally friendly fuel? 3. How is biofuel E5 used in countries around the world and Vietnam? 4. What should be paid attention to when using biofuels?
Traditional alcohol making
1. Name the specialty wines in the regions of our country. 2. What are the ingredients, tools, and traditional winemaking processes like? How does the conversion take place during winemaking? 3. What factors affect the quality and cooking time of wine? What are the local people's experiences in winemaking, and how do they judge the quality of the wine? 4. What are the economic benefits of winemaking? How are the by-products of the winemaking process handled and used? 5. Does the household-scale winemaking process pollute the environment? How do you overcome it?
Making wine from fruit
1. What kinds of fruits are often used to make wine? What are the advantages of fruit wine compared to regular rice wine? 2. What are the ingredients, tools, and processes for making wine from fruit? How to measure and monitor the alcohol content of alcohol? 3. What are the factors affecting the process of making fruit wine? How to reduce alcohol fermentation time? 4. How to preserve and use fruit wine reasonably?
Organic dynamite and the origin of the Nobel Prize
1. What organic compounds are used as explosives in practice? What are explosives used for? 2. What are the raw materials and manufacturing processes for some types of explosives? 3. What are the dangers of using explosives? 4. Where did the international Nobel Prize come from? Which chemists have recently received the Nobel Prize and their work?

Table 2. *Cont.*

Research Problems
Prepare dry-hand sanitizer
1. What are the composition and role of ingredients in dry hand sanitizer? 2. What is the ratio of ingredients, tools, and procedures to make dry hand sanitizer? 3. How to test the antibacterial ability of hand sanitizer? 4. Prepare and dilute dry hand sanitizer. How to design labels and introduce products in front of the class? 5. How to store and effectively use dry hand sanitizer? 6. How to design a simple automatic handwashing device?
Formol and food safety issues
1. In which foods is formol commonly used? 2. How is Formon incorporated into food? What effect? Why? 3. How does the use of formol-containing foods affect human health? 4. How to identify products containing formol? 5. How will the use of formol in food processing be handled?
Natural aldehydes source from plants
1. Name some plants containing aldehyde compounds. What are the structural formulas and names of these aldehydes? 2. What are methods of separating essential oils containing aldehydes like? Describe the process of separating some essential oils that you know or have locally produced. 3. What are essential oils containing aldehydes used for in life? 4. What measures to protect and develop essential oils containing aldehydes in nature?
Cinnamon/lemongrass essential oil extract
1. What is the chemical composition of cinnamon/lemongrass essential oil? 2. What are the effects of cinnamon/lemongrass essential oil in life? 3. What are the methods, processes, and tools to extract cinnamon/lemongrass essential oil? 4. Perform cinnamon/discharge essential oil extraction. How to present and introduce cinnamon/lemongrass essential oil products? 5. What measures to expand production scale? How to design a simple essential oil lamp?
Aldehyde in alcohol and how to remove
1. How is the aldehyde component in alcohol produced? 2. What does the aldehyde in alcohol affect the health of the user? 3. What is the safe limit for the concentration of aldehydes in drinking alcohol? 4. How are aldehydes removed from alcohol?
Natural sources of carboxylic acids and applications
1. What sources do organic acids come from in nature? What are their structural formulas and names? 2. Where do the common names of some organic acids come from? 3. How are natural carboxylic acids used, and what are the benefits in human life? 4. What should be paid attention to when using products containing natural carboxylic acids?
Great uses of vinegar
1. What is the composition of vinegar? What gives vinegar the sour taste? 2. What uses does vinegar have in food, and what benefits does it bring to human health? 3. What are the ingredients and the process of making rice vinegar according to the traditional method? Proceed to make rice vinegar at home. 4. What is fake vinegar? What harms does fake vinegar cause to human health? How to distinguish between rice vinegar and fake vinegar? 5. How to determine the acetic acid content in vinegar on the market? 6. What other uses does vinegar have in life?
Making vinegar from fruits
1. What fruits can be used to make vinegar? 2. What are the outstanding uses of fruit vinegar? 3. What are the ingredients and the process of making fruit vinegar? Notes in the process of making vinegar? 4. Make vinegar from fruit and introduce the product to the class. 5. What measures are used to preserve and expand the production scale?
Making yogurt at home
1. What is the composition of yogurt? Which organic acid does yogurt contain? 2. What are the benefits of yogurt for human health? 3. What are the ingredients, processes, and notes when making yogurt? How do the fermentation and the chemical reactions take place during yogurt making? 4. Make yogurt at home and introduce the product to the front of the class. 5. How to preserve homemade yogurt?
The explanation from the carboxylic acids
1. Why does the vegetable juice change color when squeezing a lemon or putting tamarind in boiled water spinach? 2. Why is there an air bubble when squeezing lemon or kumquat in shrimp paste? 3. Why does the UPSA C tablet be placed in a glass of water, causing air bubbles? 4. Why do bees or ants often apply lime or soap to reduce pain and itching? 5. Why is the aluminum pot quickly damaged when using an aluminum pot for cooking pickle soup or foods that use vinegar for a long time? 6. Why use vinegar/lemon juice to clean metal rust? 7. Why use vinegar to clean kettles or hot water containers? 8. Why use vinegar to remove the fishy smell? 9. What causes enamel damage? How to protect tooth enamel and make teeth strong and healthy?
Designing molecular models of organic compounds
1. What are the structural characteristics of organic compounds to be designed? 2. What material is the design made of? What materials are easy to find in practice? Design molecular models from selected materials. 3. How to use these models in learning? 4. How to preserve the models?

The above-proposed project topics can be done on a small or large scale with different execution times depending on the levels of complexity of research problems. In addition, students can also combine topics to make larger-scale topics that suit students' abilities.

After building project topics, lists of topics and their research problems were assessed by experts on aspects of practicality, accuracy and science, relevance, and feasibility. From the pedagogical view, practicality answers the question: Does the research problems of the project topic help link the teaching content with real life?; accuracy and science answer the question: Is the content of the problems to be solved correct and scientific?; relevancy answers the question: Are research problems suitable with the goals, teaching content, and cognitive ability of students?; feasibility answers the question: Can students find information and implement the project with current teaching conditions? Feedback from 45 experts is listed in Table 3.

Table 3. Results of expert feedback on project topics.

Criteria	Ratio %				
	Totally Disagree	Disagree	Uncertain	Agree	Strongly Agree
1. Practicality	0	0	0	0.09	99.91
2. Accuracy, science	0	0	0	33.33	66.67
3. Relevance	0	0	0	15.56	84.44
4. Feasibility	0	0	0	26.66	73.34

Table 3 shows that 100% of experts agreed and strongly agreed that the above project topics had ensured the practicality, accuracy, and science of the problems to be solved and the relevance and feasibility of project topics with teaching conditions in high schools and the goal of developing students' self-study capacity. Thus, the project topics were built in accordance with the curriculum and teaching conditions at high schools in Vietnam.

3.2. Project-Based Teaching Process According to the Blended Learning Model and Illustrated Lesson Plans

The project-based teaching process of the blended learning model was built consisting of four steps, each corresponding to specific learning activities of students organized directly in the classroom or online via the Microsoft Teams tool presented in Figure 1.

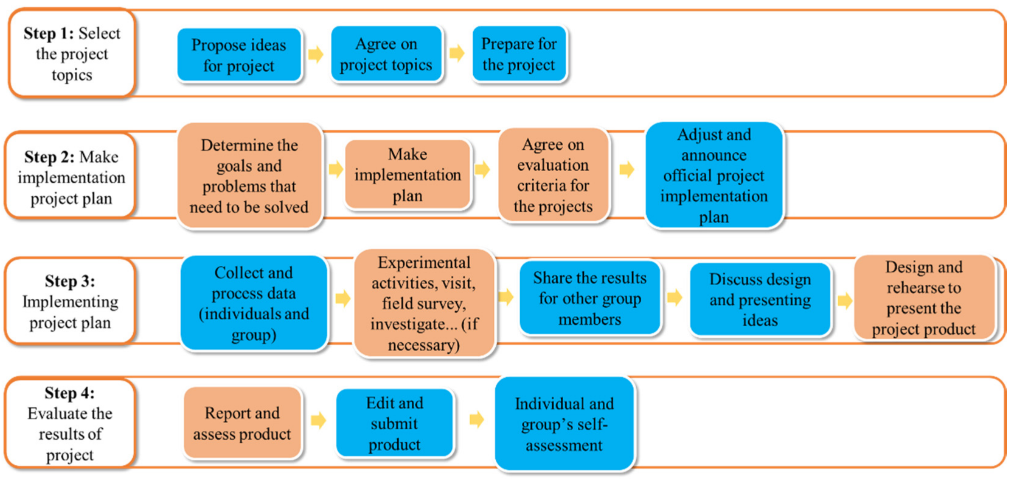

Figure 1. Four steps of project-based teaching process according to the blended learning model.

The process of organizing project-based teaching according to the blended learning model and the relationship with the self-study capacity of high school students are presented in Table 4.

Table 4. The relationship between the project-based teaching process according to the blended learning model and the manifestations of self-study capacity.

Online (via Microsoft Teams Classroom Group)	Face to Face (Traditional Class)	Manifestation of Self-Study
	Step 1: Select the project topic	
1. Students propose project ideas under the guidance of teachers on Microsoft Teams (propose names, goals, project topics that link learning content with real life). 2. Students decide to choose project topics from the topics proposed or introduced by the teacher. The teacher will survey the student's choices and publish the list of student groups working on the project. 3. Students self-identify what they already know (knowledge, skills) that is relevant and propose problems to be solved for the selected project topic; record in their notebooks. The teacher can guide the whole class on how to plan the project implementation (if needed).		- Set learning goals. - Identify what is known relevant to the learning objective.
	Step 2: Make an implementation project plan	
7. Students create private chat groups on Teams. With the teacher's support, the groups continue to discuss and adjust the project implementation plan to be more appropriate. Announce the official plan for the class group.	4. Students discuss in groups to identify what they know and what is relevant and identify the project topic's goals and research problems. 5. Students make an implementation project plan, including identifying tasks, determining the means and methods to perform the learning tasks, schedule time and expected results, and assigning tasks to the members. 6. Students discuss and agree on the project product evaluation criteria.	- Set learning goals. - Determine the means and methods to perform the learning tasks. - Schedule time and expected results to be achieved. - Cooperate with teachers and classmates.
	Step 3: Execute the project	
8. Students collect/process information to solve the project's problem as assigned in the group's plan. 10. Students share and report individual achieved results after each stage according to the plan. They highlight emerging problems, difficulties encountered for the group and teachers to comment and support settlement methods in the next phase. The teacher authorizes the group leader to manage the group, actively organize meetings, urge and remind members, and regularly report the group's results to the teacher. When all the results for each task are available, the team leader will lead the team to summarize the project results. 11. Students discuss in groups to prepare project product design ideas and develop presentation scripts.	9. Students conduct experimental activities in the laboratory at the school or visit, field survey, investigate, etc. (if necessary). 12. Groups design and rehearse to present the project products.	- Collect information. - Process information and solve learning problems. - Cooperate with teachers and classmates.
	Step 4: Evaluate the results of project	
14. Each team edits products according to teacher's and other groups' suggestions via Microsoft Teams. Teachers announce the results of project product evaluation, mental comments, and learning attitudes of individuals and groups. 15. Groups discuss in group chat to evaluate project implementation and members' contributions. Each student self-evaluates the results obtained after the project, identifies limitations and errors in the project implementation process, and proposes remedial measures.	13. Groups report the project product. Teachers evaluate and organize peer assessment of project products for students. Then announce the results and reward.	- Cooperate with teachers and classmates. - Present and defend learning results. - Assess learning results. -Learn from experience and adjust learning.

Online activities were incorporated in the steps of the teaching process to facilitate student project implementation. Specifically: In step 1, online learning shortened class time, helped students have more time to reflect on proposing and choosing topics, and provided more time to better prepare for selected project topics. In step 2, online learning facilitated the group of students' more specific exchanges with each other and with the teacher, thereby making a suitable plan; each member also had a clearer understanding of their role and group tasks. In step 3, online learning enhanced interaction and exchange in groups and between groups with teachers, and groups of students were supported by teachers timely and effectively during the implementation of the project. In step 4, online learning reduced classroom activities, giving teachers time to give detailed feedback to group and individual student activities. The different groups of students and each student also had time to reflect for better self-assessment and learned lessons. The recognition and publication of project results and online rewards also encouraged and stimulated the students' learning spirit.

Based on the above teaching process, a project lesson plan was designed in teaching grade 11 organic chemistry. Here is an illustrative lesson plan for "**Carboxylic acids in life**".

Objective:

− *Subject knowledge:* This lesson covers the following topics: natural sources of carboxylic acids and applications; great uses of vinegar; making vinegar from fruit; making yogurt at home; the explanation of acidity of carboxylic acids.

− *Competency*: Developing chemistry and self-study capacity through project-based teaching activities according to the respective blended learning model.

+ *Competence for presenting Chemistry knowledge:* Students can present the formulae, names, and benefits of carboxylic acids of natural origin and how to use them rationally; present the uses and production methods of traditional Vietnamese vinegar; present the ingredients, the process of making yogurt at home, and the benefits and ways of preserving homemade yogurt; apply knowledge of the properties of carboxylic acids to explain some related phenomena and work in practice.

+ *Self-study capacity:* Identify the goals and problems to be solved of the project topic; identify what is known (knowledge/skill) relevant to the project topic; determine the means and manner of performing the project's tasks; arrange the project implementation timetable and expected results; collect information for the above project topic from the internet, documents, and practice; information processing and problem-solving of project topics; cooperate with teachers and classmates during project implementation; present and defend project results; assess the results and the process of project implementation; learn from experience and adjust for the next project.

Qualities: Having a cooperative and sharing attitude, taking responsibility in assigned tasks, reporting truthfully, and objectively evaluating project results.

Teaching equipment and learning materials:

- Microsoft account to log in and create class groups on Microsoft Teams, computers, smartphones with an internet connection, projectors.
- Table of suggestions on goals, problems to be solved of project topics, KWL diagram, project implementation plan template, project product evaluation sheet, project performance evaluation sheet.

Learning activities:

Activity 1: Select the project topic

Objective: Students identify the goals and problems to be solved for the selected project.

Content: Students are asked to propose project topics, select topics, and identify known relevance and research problems of the selected project topic.

Product: The K and W content of the individual's KWL diagram on the selected topic.

An example of a KWL diagram of a student participating in the experiment is listed in Table S2 (in Supplementary).

Implementation process:

- *Online method on Microsoft Teams:* The teacher poses the problem to the class group: Carboxylic acids are organic compounds existing in many different forms in our lives. Humans use carboxylic acids and their derivatives in many fields such as food, medicine, agriculture, industry... Acting as a researcher investigating the role of carboxylic acids in human life, you can suggest some related project topics (specify name, objective, and expected product of the subject).

The teacher delivers the project topics for the students to choose, suggesting the following topics: Topic 1: Natural sources of carboxylic acids and applications; Topic 2: Great uses of vinegar; Topic 3: Making vinegar from fruit; Topic 4: Making yogurt at home; Topic 5: The explanation of acidity of carboxylic acids.

The teacher surveys students' choices on topics, identifying a list of student groups that work on projects under the themes. Ask each student to identify relevant known (knowledge/skills) in column K and propose problems to be solved for the project topic in column W of the KWL diagram in their notebooks.

- *Face-to-face method:* In the classroom, the teacher organizes groups of students according to the selected topic.

Activity 2: Make a project implementation plan

Objective: Students can make and adjust the project implementation plan.

Content: Groups of students are asked to set up and adjust the implementation plan under the group leader's guide and support from the teacher; agree on project product evaluation criteria.

An example of the project implementation plan of a group of students participating in the experiment is listed in Table S3 (in Supplementary).

Product: Objectives and issues to be solved of the project topics; project implementation plan of groups, criteria for evaluating project products (see in Supplementary in Table S4).

Implementation process:

- *Face-to-face method:* The teacher divides students into groups and asks groups of students to discuss and identify what is known (knowledge/skills) related to the project so that they can agree on the problems to be solved of the selected project topics (as shown in Table 1). Make a project implementation plan, assign tasks to members. The teacher guides and supports groups, suggests problems to be solved, and forms product presentations for groups of students (if necessary).

The teacher asks students to discuss and agree on the product evaluation criteria.

- *Online method on Microsoft Teams:* The teacher creates chat groups on Teams (corresponding to each student group), giving admin rights to the group leader. Support the student group to adjust the project implementation plan accordingly.

Students exchange in a group chat to adjust the project implementation plan. Agree and notify the teacher and team members of the official project implementation plan.

Activity 3: Execute the project (done in one week at home)

Objective: Students collect information and apply it to solve project problems.

Content: Students *are asked to* collect information to solve project problems according to assigned tasks and design and build scripts to present project products.

Product: Project product of thematic groups.

Implementation process:

- *Online method on Microsoft Teams:* Students perform assigned tasks, discover and propose new problems that arise to supplement and adjust the plan and project implementation activities. After each planned phase, the team leader actively creates an online group meeting in the chat group for members to report on the results of their implementation and solve arising problems. The teacher participates in group meetings to advise and support the group (if necessary).

Groups of students summarize the results obtained and propose design ideas and scenarios to present project products.

- *Face-to-face method:* Groups of students meet directly to design products and practice presenting project products. The teacher can support student groups (if necessary).

Activity 4: Evaluate the results of the project (one period in a traditional classroom)

Objective: Students present and defend the results of the project; evaluate and learn from experience.

Content: Groups of students *are asked to* present the project results; evaluate the project product through peer assessment; then each group and each student self-assess and learn from experience.

Product: Results of peer assessment of project products and self-assessment of the group's project implementation process; KWL sheet and each student's project profile.

Implementation process:

- *Face-to-face method:* The teacher arranges classroom space and organizes groups to report project products. The teacher evaluates and organizes peer assessment groups according to established criteria. Groups discuss and edit project products for submission. The teacher summarizes the results and rewards (if any).

- *Online method on Teams:* The teacher announces products and project product evaluation results and rewards active students/groups in Microsoft Teams. Each group of students self-assesses the project implementation process, and each student self-assesses and learns from experience, completes the KWL, builds a project file, and submits it to the teacher via Microsoft Teams.

3.3. The Development of Self-Study Capacity of Students Participating in Research

The experimental process was conducted in three classes of grade 11 of three high schools (high school Yen Dung No. 2, Kon Tum High School, and Go Cong High School) in three north, central, and south regions of Vietnam in the school year 2019–2020 with three project group topics about alkanes, alcohols, and carboxylic acids (Figure 2).

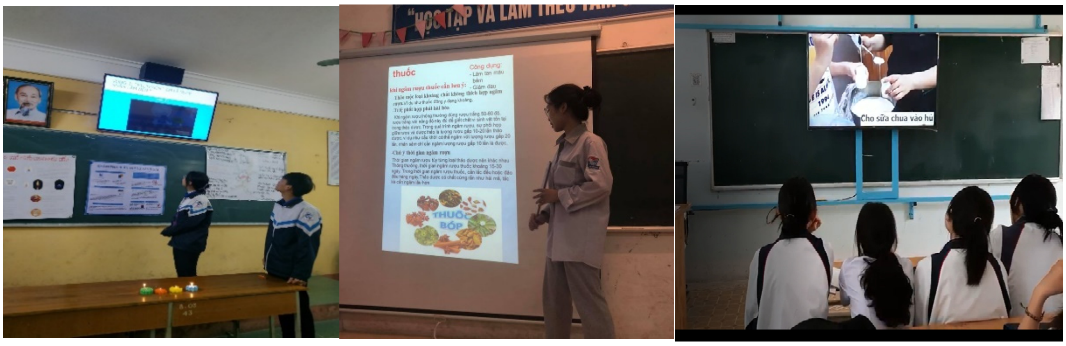

Figure 2. Illustrating images of students reporting project results.

The results of the assessment of the teacher and the students' self-assessment are presented in Tables 5 and 6 and Figure 3.

Table 5. The results of assessing students' self-study capacity before and after the experiment through the teacher's assessment.

Assessment Criteria *	*Frequency of Students Getting Grades*						*Standard Deviation*		*Difference of Means* **	*t-Test (Sig.)*
	Level 1		**Level 2**		**Level 3**					
	before	**after**	**before**	**after**	**before**	**after**	**before**	**after**		
1	32	3	82	43	11	79	0.56	0.54	0.78	<0.0001
2	33	6	82	84	10	35	0.56	0.53	0.42	<0.0001
3	53	4	65	75	7	46	0.59	0.54	0.70	<0.0001
4	52	6	72	94	1	25	0.51	0.48	0.56	<0.0001
5	37	2	80	68	8	55	0.56	0.53	0.66	<0.0001
6	43	2	82	88	0	35	0.48	0.47	0.61	<0.0001
7	33	0	86	65	6	60	0.52	0.50	0.70	<0.0001
8	39	0	76	79	10	46	0.58	0.48	0.60	<0.0001
9	42	6	81	100	2	19	0.50	0.44	0.42	<0.0001
10	44	6	80	101	1	18	0.49	0.31	0.44	<0.0001

* The criteria are numbered in Table S1. ** As the difference of the mean of before and after impact.

3.3.1. Teacher's Assessment Results

After collecting the data, the obtained data were synthesized and analyzed using SPSS 20 software. In each criterion of students' self-study capacity assessment (from 1 to 10), the frequency of each level in each criterion was recorded, the standard deviation and the mean difference were determined, and a *t*-test was performed to determine whether the difference in the evaluation results of each criterion between before and after the experiment is statistically significant or not. The results are summarized in the table below:

Similarly, the mean values of the total criteria were analyzed and compared before and after the experiment in Table 6.

Table 6. Comparison of the average mean values of 10 criteria before and after the impact through the teacher's assessment.

Group	Mean	Std. Deviation	Difference of Means	*p* (Sig.)	ES
before	1.72	0.40	0.59	0.000	1.48
after	2.31	0.31			

3.3.2. Student Self-Assessment Results

The results of students' self-assessment are statistically shown in Figure 3.

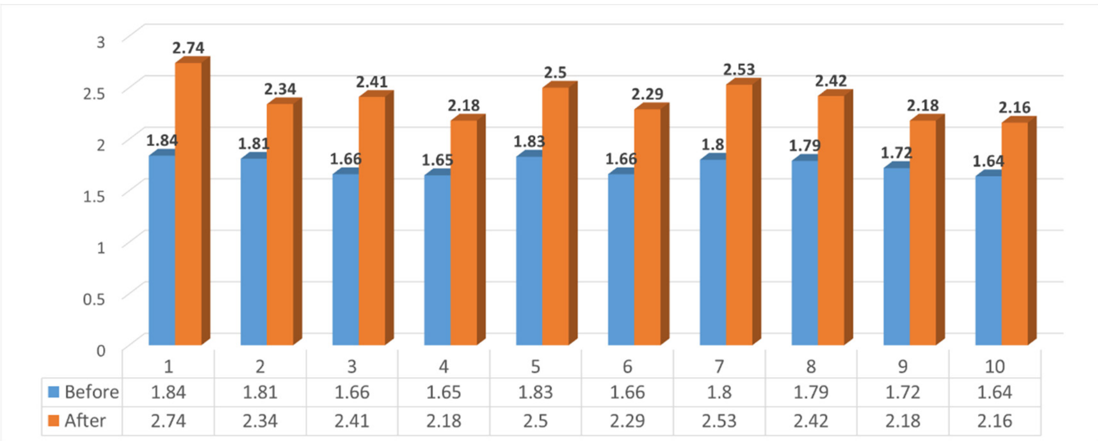

Figure 3. Comparing mean values of the development of students' self-study capacity between before and after the experiments through the students' self-assessment.

4. Discussion

The knowledge of the organic chemistry of hydrocarbons and hydrocarbon derivatives at high school is very close to daily life and suitable for selection in project teaching. According to experts' assessment of proposed project topics, 11 project topics related to hydrocarbons and 19 topics related to hydrocarbon derivatives knowledge are suitable for the curriculum and teaching conditions at high schools in Vietnam. The system of research problems (research questions) for proposed topics covered practicality, accuracy and science, relevance, and feasibility. These research problems are the basis for students to identify tasks and plan to implement the project in the next stage.

According to the teacher's assessment results, the evaluation results of each criterion and the average of the criteria of self-study capacity in students after the impact increased significantly compared to the time before the impact (effectiveness number of after–before > 0). The most significant difference was in the criteria: 1 (setting learning goals), 3 (determining the means and methods to perform the learning tasks), 5 (collecting information), 6 (processing information and solving learning problem), 7 (cooperating with teachers and classmates), and 8 (presenting and defending learning results). This change was not due to chance but due to impact because the value of Sig. in the *t*-test was always less than 0.05. Not only that, but the level of impact of the measure was also quite high (ES = 1.48). This reflects the development of students' self-study capacity through the experimental process.

The data in Figure 3 showed that the scores of students' self-assessment for the criteria of self-study capacity after the experiment were all higher than those of before the experiment, especially the criteria with a large fluctuation range of 1 (0.9), 3 (0.75), 5 (0.67), and 7 (0.75). This was quite similar to the teacher's assessment and once again proved that the learning by the project-based teaching process according to the blended learning model positively impacted developing students' self-study capacity.

By observing students' attitudes and interests and interviewing students during the experiment, we found that students in experimental classes were very lively, active, and excited about implementing projects, learning, especially with the presentation, debate, and evaluation of project products. Many students expressed that they were able to develop ideas together, plan their group's projects, find information, and interact more with each other through the online environment.

The teachers participating in the experiment also gave positive feedback. Based on their opinions, the organization of teaching and learning according to the blended learning model helped teachers and students conduct project activities easily and flexibly. With the online environment, teachers provide timely and effective help for each group and better monitor and evaluate students' activities throughout the project implementation process including the ideation stage, selecting topics, proposing problems to be solved, planning, implementing the plan, presenting, debating to defend the project results, and evaluating and drawing lessons. The interaction between students in the group was also significantly enhanced, leading to increased project teaching results and students' self-study ability. Through this, students were trained and comprehensively developed knowledge and skills, including information technology skills.

Thus, the positive feedback of both teachers and students also partly reflected the feasibility and effectiveness of applying project teaching according to the blended learning model in developing students' self-study abilities, contributing to affirming the validity and practical significance of this study.

5. Conclusions

The trend of applying technology in education has been increasingly evident globally, which creates good conditions for education to fulfill its essential mission. Blended learning is an inevitable trend, helping to combine the strengths of both online and face-to-face methods in teaching.

The Grade 11 Organic Chemistry section in the Vietnamese General Education Program has much content related to real life, which is very suitable for organizing project-based teaching. For project-based teaching to be effective, especially in developing students' self-study capacity, it is necessary to be organized according to the blended learning model. Thirty project topics with detailed research problems were built by studying the content characteristics of the organic chemistry part of grade 11. The suitability of the proposed topics was assessed on aspects of practicality, accuracy and science, relevance, and feasibility. The process of organizing project-based teaching with a combination of online teaching activities was also proposed. The teaching effectiveness was proven through the experimental process at three high schools representing three regions of Vietnam; the results show a clear development of the self-study capacity of students participating in the experiment.

From the research results, we made the following recommendations:

(1) It is necessary to continue to promote research to expand the application scope of blended learning in general and project teaching according to the blended learning model in particular in other contents of the Chemistry subject and other subjects.
(2) High schools need to focus on investing in building facilities, especially investing in online teaching systems and tools (can use Microsoft Teams, Facebook, Google Classroom, Moodle, Edmodo, etc.), support and encourage teachers in blended

learning organizations, and enhance training in information technology skills and teaching skills according to the blended learning model for teachers. However, schools should properly assess their actual conditions to have an appropriate blended learning teaching plan.

(3) Teachers need to investigate students' learning conditions to propose appropriate plans for organizing blended learning teaching. Teachers should also flexibly apply methods to manage students' online self-study activities in the process of teaching, such as organizing cooperation in self-study, setting specific requirements (products and deadlines) with self-learning tasks, delegating authority to the group leader in managing the group, and timely evaluating, motivating, and encouraging students after each learning stage.

Finally, this research result contributed to meeting the requirements of educational innovation toward developing the quality and capacity of students in the current period and is a useful reference source for teachers in the process of implementing the new General Education Program in Vietnam.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/educsci11070346/s1, Table S1: Criteria and level of assessment of students' self-study competency in project teaching according to the blended learning model, Table S2: KWL diagram of a student participating in the experiment, Table S3: Project implementation plan of a group of students participating in the experiment, Table S4: Criteria for evaluating project products.

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