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Project Based Learning in General Chemistry to Develop the Problem-Solving and Creativity

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Abstract Project Based Learning is one of the modern learning methods. However, at present there are not many project-based learning materials to develop problem-solving and creative capabilities for students of technical universities in Vietnam. Therefore, the research and application of project-based learning through the general chemistry module to develop problem-solving and creative capacity for students is very necessary. This article will be introduced the general chemistry course under the project based learning method to develop problem-solving and creative capacity for technical university students.

Keywords: *project based learning, problem solving and creativity, general chemistry, technical university students*

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1. Introduction

Currently, higher education in Vietnam is being concerned to improve the quality of training to meet the requirements of the country's development career. Thomas J. Vallely and Ben Wilkinson, 2008 at Harvard's Kennedy school, wrote about crisis and solutions for the development of higher education in Vietnam [1]. However, Ngo Tu Lap, Director of the Francophone International Institute (IFI) said that the crisis of higher education in Vietnam was a crisis of development [2]. In the process of fundamental and comprehensive renovation of education, innovating teaching methods is very interested in Vietnam [3,4,5,6,7]. The project based learning is one of the modern learning methods, attracting the attention of many teachers, lectures and educational researchers [8,9,10,11,12,13]. Nguyen Ngoc Duy has developed a set of assessment tools for problem solving and creativity for high school students in teaching non-metallic chemistry projects [14]. At technical universities in Vietnam, the general chemistry course is taught with a duration of 45 hours (equivalent to 03 credits), applied to first-year students. With a rich amount of knowledge, skills and practical relevance, it is possible to apply project based learning to develop problem-solving and creative capabilities for students.

2. Research Content

2.1. Concept of Creative Problem Solving and Creativity

So far, the concept of problem-solving and creativity has many different definitions that reflect the different aspects of this concept. However, according to the concept of competency outlined in the document [3], "Problem solving and creativity in learning is the ability to solve learning problems to find new things to some degree. In order to be able to solve problems and be creative, the subject must be in a problematic situation, find ways to resolve cognitive or action conflicts and as a result, devise new solutions to solve them." Problem solving and creative capacity structure includes five components: Identify and clarify problems; forming and deploying new ideas; proposing and selecting solutions; implementation and evaluation of problem solving solutions; creative thinking. Each element includes a number of individual behaviors when working in groups or working independently in problem solving.

From the research results of problem solving and teaching practice of general chemistry course at technical university, we propose the expression of students' ability to solve problems and creativity through teaching. Study under the project as follows:

Table 1. Criteria of creative and problem solving capacity

Component capacity	Criteria	Level		
		1	2	3
Detect and clarify problems	Identify and present problematic learning situations			
	Analyze and clarify the situation in learning			
Forming and implementing new ideas	Gather information related to the problem and form new ideas			
	Propose solutions to improve or replace solutions that are no longer appropriate			
Proposing and selecting solutions	Proposing some solutions to solve the problem			
	Choose to solve the problem			
Implementation and evaluation of problem solving solutions	Evaluate the problem-solving solutions			
	Receive and evaluate problems from different perspectives			
Creative thinking	Receive and evaluate problems from different perspectives			
	Apply the solution to a new context			

2.2. Project Based Learning

Project based learning is an important method to implement learner-oriented teaching perspective. Project based learning helps develop 21st century skills through open tasks, encouraging learners to explore and actualize the knowledge learned in the implementation process and create products by yourself. Project based learning contributes to link theory with practice, thinking and action, schools and society, actively participates in the training of autonomy, creativity, solving complex problems, sense of responsibility and the ability to collaborate and work for learners.

Project Based Learning has been widely applied in the world, but it is still quite new in Vietnam. Although there are different interpretations on the project, the authors Nguyen Thi Dieu Thao [9], Vu Thi Yen [10] and Pham Hong Bac [11] all think that the project is an operational plan, with target, clear purpose, implemented under defined conditions. As such, the Project is an operational plan aimed at achieving a predetermined goal, carried out under certain conditions, limited by time, manpower and material resources. Phan Dong Chau Thuy author [12] wrote that "A project is a plan, a specific plan to accomplish a certain goal, to be implemented within a limited time period, with the defined human, material and financial resources to satisfy needs of the people that the project targets. Learning projects should be linked to learning products, this product is created by learners under the guidance of lecturers.

The eight characteristics of the project based learning (PBL) are shown in Figure 1.

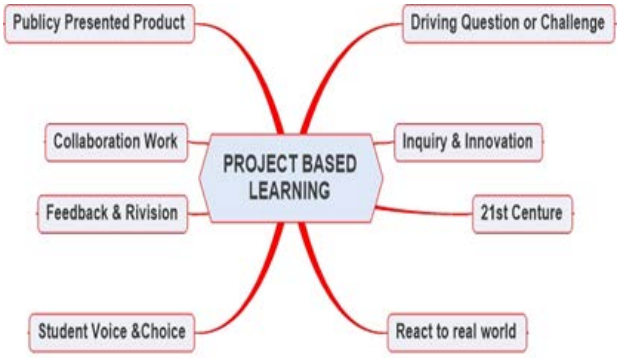

Figure 1. Characteristics of the project based learning

Why apply project based learning? The answer of this question is shown in Figure 2.

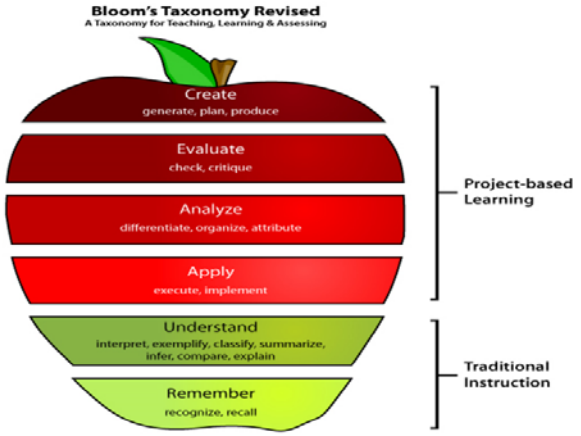

Figure 2. Project based learning oriented higher-level thinking

Since then, we believe that: In Project Based Learning, students go through an extended process of inquiry in response to a complex question, problem, or challenge. Rigorous projects help students learn key academic content and practice skills such as collaboration, communication & critical thinking. Project Based Learning helps make learning relevant to students by establishing connections to life outside the classroom and by addressing real world issues. In the high education, Project Based Learning gives lecturers an opportunity to build relationships with students by acting as their coach, facilitator, and co-learner.

2.3. The Process of the Project Based Learning

There are many ways to divide the stages of a project based learning process [9,10,11,12,13]. With the goal of developing students' problem-solving and creativity capacities, the process of project based learning includes 05 phase as follows:

Phase 1. Project construction. Lecturers propose ideas on the topic of a learning project by giving a problematic situation or a task to be solved. The project name may be proposed by lecturers, students or groups but must ensure that the content is consistent with the learning goals, program content and practical conditions. Facilitators can also introduce a number of topics for students to choose, discuss, and clearly identify the goals, the requirements to be achieved by the project. Lecturers divide the class into groups to suit the tasks of the project, with the capacity of each student.

Phase 2. Planning the implementation. Students discuss in groups the goals of the project, come up with solutions and choose a project implementation solution, identify the tasks to be done, then split the work and assign it to real team members. show up. Tasks of each group and individual should be specific, detailed on the content of work, how to proceed, and time for completion. Lecturers base on the project goals, project execution time fund and student deployment plan to get suggestions and corrections to help students implement the right direction.

Phase 3. Project implementation. During this period, active groups take the initiative in carrying out their assigned tasks, seeking specialized knowledge related to the learning project. While implementing a learning project, students need to increase exchanges between team members and between groups. Especially, when implementing a project, students need to stick to their goals to make timely adjustments. Instructors need to monitor and adjust student activities so that the project implementation process reaches the set goals.

Phase 4. Report the project results. The results of the project are products that can be introduced, presented to the group or in front of the class. The students can introduce the results such as reports, presentation, infographic, etc...

Phase 5. Evaluation of project results. The process of assessing results may be conducted by individuals or groups who self-assess the results of themselves, groups, individuals or other groups. Lectures are the last person to evaluate and make general comments about the project implementation process and the products obtained. Then propose ideas of new projects.

2.4. A Case Study Project "The shift of chemical equilibrium and life"

2.4.1. Objective of the Project

After the project, students achieve the following goals:

- About knowledge: Through the project, students can present the concept of the equilibrium constants Kc, Kp; Factors affecting chemical equilibrium include concentration, temperature, pressure.
- About skills: Detecting and bringing out some practical problems, solving problems through known knowledge; collecting information and processing information; Cooperate in teamwork, plan and perform personal tasks to accomplish common team tasks. Idea, product design. Experimental organization.
- Attitude: Raising awareness of environmental protection, caring, protecting and taking care of ourselves and others; actively take the initiative in planning scientifically and effectively; improve the spirit of cooperation, teamwork.
- Regarding capacity development: Capacity for problem solving and creativity; Competence in using digital technology; Communication and cooperation competence; Self-learning ability.

2.4.2. Progress of the Project Based Learning

The process of teaching under the project "The equilibrium and life shift" in teaching general chemistry to technical university students to develop problem-solving and creative capacity is carried out as the Table 2 follows:

Table 2. Project learning process "The shift of chemical equilibrium and life"

Contents	Activates of lectures	Activates of students	Develop the Problem solving and creativity
Phase 1. Project construction			
-Identify the project name -Determining project objectives	-Introduction to the project based learning. -Introduction topic "The shift of chemical equilibrium and life". -Assign tasks to groups. Introduce documents, sources of information to look up.	-Discuss to identify the project name, project objectives. -Proposal of questionnaires that guide the topic. Learn real-world chemistry; Document research to solve practical problems.	-Identify and identify problematic learning situations; -Analyze the situation in learning. -Receive specific group responsibilities and assignments to each member.
Phase 2. Planning the implementation			
-Write a project plan that includes the objectives, content, measures and expected products. - Design the product evaluation criteria of the project.	-Listen to the groups presenting the project implementation plan. -Suggest and orient groups to choose problem-solving solutions. -Comment on the plans of the groups on the goals, contents, measures, resources, time, ...	Group 1. Plans a study of equilibrium shifts in the synthesis of ammonia. Group 2. Plans a study of equilibrium shifts in calcination. Group 3. Plans a research on equilibrium carbon dioxide in the atmosphere	-Proposing some solutions to solve the problem; Choose a solution to solve the problem. Gather information relevant to the problem and form new ideas; -Propose solutions to improve or replace solutions that are no longer appropriate.
Phase 3. Project implementation			
-Learn knowledge and skills related to chemical equilibrium. -Solve practical chemistry problems creatively	-Check the project implementation progress of the groups, each individual in the group. -Adjust the project progress in accordance with the implementation of the program content	-Learn about the factors that influence chemical equilibrium including concentration, temperature, and pressure. -Apply knowledge and skills to implement project solutions.	- Implementing the problem-solving solutions. -Creativity, novelty of problem-solving solutions
Phase 4. Report the project results			
-Write a project final report. -Each group presents the project's products and a project summary report	-Organize reporting groups, presenting project implementation results. -Coordinate discussion and review of projects	-The representative groups report results. -Answer questions from other groups and lectures. -Finalize the group report.	-Solve problems when presenting, discussing and criticizing. -Develop creative thinking through receiving and reviewing problems from different perspectives.
Phase 5. Evaluation of project results			
Evaluate the level of reaching the learning goal of the project.	-Organize evaluation groups and comments based on predetermined criteria. -Overall evaluation of project results	-Self-assessment and cross-evaluation of project results of the group. - Complete the project report of the group.	Evaluate the develop of the problem solve creativity

2.4.3. Assess Problem Solving and Creativity

To assess the level of developing problem-solving and creative capacity for students through teaching under the general chemistry module project at technical universities, we have built a evaluation toolkit. This set of tools has a combination of observation checklist assessing of problem solving and creativity and writing test. The writing test is specially designed according to the criteria of problem solving and creativity. The observation checklist evaluating problem solving and creativity is showed in Table 3.

Table 3. Observation checklist evaluating problem solving and creativity for Project Based Learning

Project topic name: .....
Student's name: .....
Name of lecture:…….

Numerical order	Criteria	Level		
		1	2	3
1	Identify and present problematic learning situations			
2	Analyze and clarify the situation in learning			
3	Gather information related to the problem and form new ideas			
4	Propose solutions to improve or replace solutions that are no longer appropriate			
5	Proposing some solutions to solve the problem			
6	Choose to solve the problem			
7	Evaluate the problem-solving solutions			
8	Receive and evaluate problems from different perspectives			
9	Receive and evaluate problems from different perspectives			
10	Apply the solution to a new context			

2.3. The Pedagogical Experiment

In the 2018-2019 academic year, conducting pedagogical experiments for first-year students at 3 universities (University of Information Technology and Communications - Thai Nguyen University; Hanoi University of Industry; An giang University - Ho Chi Minh National University), experimenting with the project "The shift of chemical equilibrium and life" ; Pedagogical experiment with the participation of 04 lecturers (Nguyen Ngoc Tuan; Ma Thi Van Ha; Nguyen Duc Hai; Trang Quang Vinh) with 124 students in 03 experimental classes. Conducted assessment of students' problem-solving and creativity abilities through observation checklist; the written test is used for the experimental and control classes after teaching experiments to assess students' ability to solve problems and creativity.

Assessment of problem-solving and creative ability for students through checklist of pre-impact and post-impact observation is presented in Table 4.

Table 4. The parameters feature the statistical results of the observation checklist

	Before impact	After impact
Average Score	1.41	1.79
Standard deviation S	0.22	0.13
T-test independent	$9.9*10^{-5}$	
ES	1.72	

Based on the above-mentioned statistics and data analysis, the students' ability to solve problems and creativity after studying the project has been significantly improved. Independent T-test less than 0.05 showed that the difference of average points before and after the impact is statistically significant. ES = 1.72 at the impact level of the large impact. From that, it can be concluded that teaching under the general chemistry module project is effective and highly feasible, can be widely applied in technical universities.

In addition, the special tests are designed to assess students' ability to problem solving and creativity.

The cumulative results of the experimental and control classes test points are shown in Figure 3.

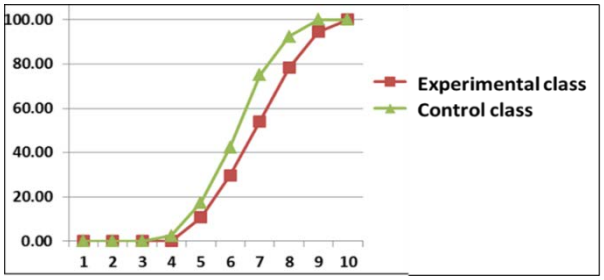

Figure 3. Cumulative test scores for experimental class and control class

The graph of accumulated test scores of experimental class is always on the right and below the cumulative lines of the control class. This proves that the students of the experimental classes meet the requirements and goals of the PBL better than students in the control class. Pedagogical experiment results assessed through 124 tests (63 control students, 61 experimental students), are presented in Table 5.

Table 5. Statistical parameters of the test

Class	Experiment	Control
Average Score	7.46	6.05
Standard deviation	1.69	1.76
t-test independent	$1.4*10^{-8}$	
ES	0.8019	

The average score of experimental classes is higher than the control classes. However, it is impossible to conclude that project based learning is more effective than traditional teaching. The independent T-test has $p = 1.4 * 10^{-8} < 0.05$. So it can be seen that the difference in the average score of the experimental classes and the control classes is not likely to occur randomly but by the impact of project based learning.

3. Conclusions

Project based learning is very effective and necessary for higher education in Vietnam today, in order to stimulate creativity, passion, scientific discovery for students, meeting the needs of high quality human resource training for the country's sustainable development. Through learning in the project "The shift chemical equilibrium and life" has developed the ability to solve problems and creativity for students, this makes the general chemistry course closer to life of the students,

combining theory with real life, applying scientific and technical advances. The results of pedagogical experiment confirmed the improvement of problem solving ability and creativity of experimental students after the impact is higher than before impact is statistically significant and this research has a coefficient. The impact is to a large extent, so it can be replicated.

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