

Developing Students' Problem-Solving Capacity through the Teaching of Integrated Natural Science in Secondary Schools in Vietnam

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Abstract Currently, Vietnam's Ministry of Education and Training is implementing significant reforms in national general education. One of the main goals of new general education curriculum is to develop students' capacity. This paper presents findings of the research on the development of problem-solving capacity through the use of Project-based Learning Method and Problem – based Learning Method in the teaching of integrated natural science in secondary schools.

Keywords: *integrated teaching, natural science, capacity, problem-solving capacity, secondary school*

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1. Introduction

Problem-solving capacity refer to the ability of using cognition, actions, and attitudes, motives and emotions to cope with situations and problems where there are no available common procedure and solutions [1]. As for learners, problem-solving capacity is an essential capacity in the learning process that can help them to deal with the fast-changing pace of life, and to meet demands for new workers in the process of integration and development. Noted in General Education Curriculum released by Vietnam Ministry of Education and Training in July 2017, problem-solving capacity and creativity are essential elements that should be built and developed for students by teaching and educational activities in secondary schools [2].

Globally, many studies on problem-solving capacity and the teaching activity that can develop problem-solving capacity have been conducted by psychologists, philosophers and educators. The concept of capacity has been long introduced to the world. According to Mulder, Weigel and Collins, the concept "capacity" was first used in Plato's (Lysis 215 A., 380 B.C.); it then became popular, and started to be studied in the 1970s of the 20th century [3]. So far, there have been a wide range of definitions of and approaches to "capacity" suggested by different organizations and individuals, such as OECD (2002) [4], Québec - Ministère de l'Éducation (2004) [5], F.E. Weinert [6], Howard Gardner [7], Tremblay [8], ... However, it can be easily seen that most researchers

agreed that capacity refers to the ability that an individual has in combining knowledge, skills, and attitudes to successfully solve a problem in a certain context.

In Vietnam, there have been studies on the development of problem-solving capacity for students in teaching Chemistry conducted by Nguyen Thi Phuong Thuy, Nguyen Thi Suu, Cao Thi Thang,... In these studies, the authors wrote about characteristics, structures, and manifestations of problem-solving capacity and also proposed some solutions in developing students' problem-solving capacity, namely Project-based learning, and Problem-based learning. However, they still have no research on the development of problem-solving capacity for students by teaching integrated natural science in secondary schools [9,10].

Integrated teaching is an educational concept built on the basis of positive views on teaching and learning process. This gives guidance in teaching process to build and develop students' capacity, linking the teaching and learning process with the practice. During the learning process, not only are students provided with knowledge about the world and specific skills of each subject but they are also helped to develop their practical skills, especially the ability to combine the knowledge of different subjects to discover and tackle problems in real life. Integrated teaching is applied in developing general education curricula in many countries with well-known education in the world such as Australia, England, America, Canada, Germany, Singapore and etc. This clearly demonstrates the important roles of integrated teaching in the development of capacity for students [11,12,13,14].

In conclusion, integrated teaching is considered the bridge to connect the learning process with the real world and the development of students' capacity. In teaching subjects of science in secondary schools, integrated teaching shows considerable educational effectiveness. It is described as a time-saving, cost-saving and labor-saving teaching method. Furthermore, it helps stimulate students' learning interests, improve their critical thinking and creativity and develop their problem-solving skills so that they can deal with more complicated problems in their real lives, trying to become more knowledgeable, energetic and creative students to meet the demands of the modern society. Although integrated teaching has been long studied and implemented in many parts of the world, it is still a new concept in Vietnam which is initially being employed in the renovation of course book and teaching curricula. In this paper, we aim to present the research findings on the development of problem-solving capacity for students by teaching integrated natural science in Vietnam's secondary schools.

2. Content

2.1. Research Methodology

During the study, we combine the use of groups of research methods namely theory-based research, experimental research and data analysis. The procedure of the study is presented as follows:

Step 1: Collect, select and analyze the data about the situation of teaching integrated natural science to develop problem-solving capacity for students in secondary schools.

Step 2: Based on findings about the situation, suggest solutions to the development of problem-solving capacity by teaching integrated natural science in secondary schools.

Step 3: Conduct micro-teachings to evaluate the effectiveness and the feasibility of the suggested solutions in the development of problem-solving capacity by teaching integrated natural science in secondary schools.

The data of the research are collected and analyzed with the use of the software SPSS 22 (Statistical Package for Social Science). Here are specific results of the research.

2.2. Research Results

2.2.1. The Situation of the Use of integrated Natural Science Teaching to Develop Problem-solving Capacity for Students in Secondary Schools

To collect data for the research, we designed questionnaires about the development of problem-solving skills for students through integrated teaching of the natural science and then distributed them to 250 teachers who are currently teaching subjects of Physics, Biology and Geography in 85 secondary schools in several provinces in the North, Central and South of Vietnam. The results showed that 93.6% of teachers have ever applied integrated teaching. It means that most of the surveyed teachers have had access to integrated teaching and applied it in their classrooms. Moreover, in order to evaluate the influence of the teacher's age on their integrated teaching, we compared the correlations between the age of the teachers and the effectiveness of their integrated teaching. Results are shown in Table 1.

From Table 1, it can be seen that the correlation coefficient between the two variables Age and Integrated teaching is $r = -0.265$, which is an inverse and low correlation. $\text{Sig.} = 0.000 < 0.05$ indicates that the correlation between the two variables is statistically significant. Thus, the age of the teacher participants have almost no influence on their integrated teaching of natural sciences in secondary schools. In other words, the age is not the factor that decides whether or not the teachers applied integrated teaching in their classrooms.

Having analyzed the data about the frequency of the use of integrated teaching, we have the findings as presented in Table 2.

Table 2 shows that teachers surveyed often used integrated teaching in association with their lessons of separate subjects. This is quite appropriate to the existing curriculum of general education in Vietnam. However, this way seems to be the least effective of integrated teaching as it does not give students opportunities to deal with problematic situations where they have to combine their knowledge and skills learnt from different subjects to accomplish successfully the task assigned.

Table 1. Correlations of teachers' age and their integrated teaching

Correlations			
		Age	Integrated teaching
Age	Pearson Correlation	1	-.265**
	Sig. (2-tailed)		.000
	N	250	250
Integrated teaching	Pearson Correlation	-.265**	1
	Sig. (2-tailed)	.000	
	N	250	250

** . Correlation is significant at the 0.01 level (2-tailed).

Table 2. The frequency of the use of integrated natural science teaching in secondary schools

Main content	The frequency of using integrated natural science teaching				
	Always	Often	Sometimes	Rarely	Never
Integration into lessons of separate subjects	39,3%	55,1%	5,6%	0,0%	0,0%
Application of interdisciplinary knowledge	0,0%	26,5%	64,5%	8,5%	0,4%
Application of interdisciplinary knowledge in learning projects	0,0%	1,3%	29,5%	52,6%	16,7%

Table 3. Teachers' opinions on the importance of using some active learning methods in integrated teaching to develop students' problem-solving capacity

		Statistics					
		DT5.1	DT5.2	DT5.3	DT5.4	DT5.5	DT5.6
N	Valid	233	234	234	234	234	234
	Missing	17	16	16	16	16	16
Mean		1.3176	1.6538	2.3462	2.3846	2.2265	1.3120
Std. Deviation		.46654	.84142	.67754	.78446	.74981	.46429

Meanwhile, teachers sometimes use interdisciplinary knowledge in integrated teaching (with 64.5%). Particularly, the application of interdisciplinary knowledge is still limited, as it is used in lessons designed for a visit or a competition. The proportion of interdisciplinary knowledge used in learning projects is very low, which indicates that the interconnection of different subjects in the teaching process is not highly regarded. This is an explicit example of the current teaching situation in Vietnam where the majority of teachers are trained to teach separate subjects while they have little access to integrated teaching through some short training courses provided by Ministry of Education and Training (with 90% of total number of secondary school teachers taking part in the training courses). Correspondingly, the implementation of integrated teaching causes many difficulties, including the lack of teacher's knowledge and qualifications and some other external factors namely lack of facilities, time and social demands. This leads to the inadequate efficiency of integrated teaching in secondary schools.

As for the application of integrated teaching, it is necessary for teachers to combine methods of active learning to maximize students' active involvement and creativity in their learning process. On surveying teachers, we collected their opinions on the importance of using some forms of active learning in integrated teaching to develop problem-solving capacity for students. When analyzing the data, we named the teaching methods as: Problem-based Learning method (DT5.1); Project-based Learning Method (DT5.2); "Working in Corners" Method (DT5.3); Web Quest Learning Method (DT5.4); Hands-on Method (DT5.5); Authentic and Situated Learning Method (DT5.6); and the importance levels of the use of the teaching methods are described as Very important (1); Important (2); Quite important (3); Little Important (4); Not important at all (5). The results are illustrated in Table 3.

By looking at Table 3, it can be seen that teachers

regard Problem-based Learning (mean = 1.3176), Project-based Learning (mean = 1.6538) and Authentic and Situated Learning (mean = 1.3120) are important in integrated teaching to develop students' problem solving skills. These are active learning methods that enable the connection between student's theory learning and the practice. Hence, it is really necessary to apply these teaching methods in the teaching of integrated natural science to develop problem-solving capacity for students in secondary schools [15].

2.2.2. The Application of Project-based Learning and Problem-based Learning Methods into the Teaching of Integrated Natural Science to Develop Problem-solving Skills for students in Secondary Schools

We have developed 11 topics from the integration of natural science subjects currently taught at secondary schools, including Atomic, chemical elements, compounds and molecules; The air around us; Water – A Resource for Life; Acid and Base in our life; Chemical fertilizers with Plants and soil environment; Carbon and carbon compounds – Climate Change; Methane and Biogas - The Green Energy; Ethyl alcohol and Socio-economic Issues; Fat and human's health; Protein – The Source of Life; Polime and the Recycling Festival. In addition, we combine the Problem-based Learning Method and Project-based Learning Method with other active learning methods and techniques to teach some modules of integrated teaching with the aim of developing problem-solving skills for students in secondary schools. Below are some topic-based teaching activities we designed:

Example 1: *Applying Problem-based Learning Method in teaching the module: "The importance of chemical elements to the plants, and different types of chemical fertilizers" in the integrated topic "Chemical fertilizers with the plants and soil environment"*

Activity 1: Assign tasks, hold discussions, discover and state the problem (20 minutes)

Learning Tasks

1. Which essential nutrients are needed for the development of a plant?
2. Name some essential macronutrients, secondary macronutrients and micronutrients for the development of a plant
3. How important are macronutrients, secondary macronutrients and micronutrients to the development of a plant?
4. What are common signs of malnutrition of a plant?
5. In what ways can plants assimilate its nutrients? In what ways can the plant be provided with inadequate nutrients?
6. Is it true that the more chemical fertilizers the plant is provided, the more the plant grows?

Teacher's activities	Students' activities	Indications of problem-solving capacity development
<ul style="list-style-type: none"> - Teacher (T) divides students (Ss) into small groups to identify the roles of chemical elements to the plants and different types of chemical fertilizers. - T tells groups about the goals, main content, techniques, procedure and time of activity). T asks each group to make a plan for the activity. - T asks Ss to watch videos about the factors affecting the development of a plant. T asks them to collect data about the roles of chemical elements to the development of the plant, and then present the findings on an A0 paper. - T asks, by turns, one group to present their project's findings, and other groups listen, discuss and give feedback. - Based on the discussion, T instructs ss to state the problem. 	<ul style="list-style-type: none"> - Ss divide themselves into smaller groups as required. - The groups take on the learning project - The groups make plans for their projects, assign responsibilities, and perform the tasks to complete the project - In groups, Ss work collaboratively to study the materials and complete the assigned tasks - Representative members of the groups present the project findings and other groups listen and discuss. In the discussion, ss may face some difficulties in understanding the roles of chemical fertilizers and their uses. - Ss state the problem: In what effective ways can chemical fertilizes be used? 	<ul style="list-style-type: none"> - Analyze and identify goals, and requirements of the learning project - Make plans for the project - Propose, select and decide the most suitable solutions to the problem in the integrated topic. - Collect, analyze and use interdisciplinary knowledge to complete the learning tasks. - Complete successfully the project plan - Figure out and report the project findings in a well-organized, scientific and creative way.

Activity 2: Instruct students to perform the learning tasks, discuss and find out the solutions to the problem stated (45 minutes)

Teacher's activities	Students' activities	Indications of problem-solving capacity development
<ul style="list-style-type: none"> - T puts Ss into groups to investigate and propose solutions to problem. - T lets Ss report their research findings, discuss the proposed solutions and then guide them to choose the best solution. - T asks Ss to work in groups, in combination with matching method, to find out characteristics of each type of chemical fertilizer, using the questions as clues below: <ol style="list-style-type: none"> 1. What nutrients does the fertilizer give to the plant? Which nutrient is used to measure the nutrition level of the fertilizer? 2. What is the use of the fertilizer and how can it be kept? 3. What is the classification of fertilizers and what is the use of each type? 4. How can fertilizers be produced? 5. What needs to be noted about the use of fertilizers? 	<ul style="list-style-type: none"> - In groups, Ss discuss and propose solutions to the problem. Present the results on an A4 paper. - Ss select the best solution: Study the materials to find out the roles of each type of chemical fertilizer in the development of the plant and how to use them properly and effectively. - Ss in groups work out the plan of the project, and then perform the tasks assigned. On completing the learning tasks, they discuss the project findings and draw conclusions. 	<ul style="list-style-type: none"> - Propose the solutions and then select the most appropriate one to the topic. - Collect, analyze and combine knowledge of different subjects to complete the learning tasks. - Perform the tasks assigned in an effective way. - Complete the project, and report the project results in an effective, scientific and creative way. - Present the project findings in a logical and scientific way.

Activity 3: Discuss, and defend the project findings and apply the gained knowledge for further studies (25 minutes)

Teacher's activities	Students' activities	Indications of problem-solving capacity development
<ul style="list-style-type: none"> - T allows Ss to present, discuss and defend their project findings in classroom and suggest improvement and further studies. - T instructs Ss to work out on the next topic of study, for example, The influence of the residue of chemical fertilizers on the soil environment and the quality of agricultural products. 	<ul style="list-style-type: none"> - Ss present the project findings, discuss and draw conclusion on the proper use of chemical fertilizers. - Ss give some recommendations for father studies. 	<ul style="list-style-type: none"> - Present the project findings in a well-organized, logical, scientific and creative way. - Apply the gained knowledge to deal with the similar or new problems.

Example 2: Apply Project-based Learning Method to teach the module "Exploiting and using water resources" in the topic "Water – A Resource of life"

Activity 1: Make project plan (15 - 20 minutes)

Teacher's activities	Students' activities	Indications of problem-solving capacity development
<ul style="list-style-type: none"> - T: <i>Based on your background knowledge of water, study the materials and then propose a learning project which is closely connected with the real world and meets demands of the society.</i> - Based on Ss' initial ideas, T leads ss to practical projects and then lets them choose the project named "<i>Exploiting and using water resources</i>" - T divides the class into 4 groups and asks them to complete the same task of the project. - T asks the groups to identify the goals, the structure and the content of the project, design a mind map for the project and then make a project plan. - T observes, supervises and supports the student groups in generating research questions, using teaching techniques, collecting data, and presenting the project findings. - T organizes in-class discussions on the procedure of the project. - T gives final criteria for project evaluation. 	<ul style="list-style-type: none"> - Based on your background knowledge of water, Ss study the materials and then give the initial ideas on learning project (using mind mapping) - Ss discuss and decide on the topic of project named "<i>Exploiting and using water resources</i>" - The group leader of each group holds and leads the discussion on performing of the following tasks: <ul style="list-style-type: none"> + Identify the goals, structure and project activities. + Propose and discuss research questions + Design a mind map of the main content and the procedure of the project + Propose a project plan, discuss with the T and complete the project plan + Assign responsibilities to group members; discuss the tasks and the expected results. - Ss discuss to figure out criteria for project evaluation. - A group member records details of the discussion. 	<ul style="list-style-type: none"> - Analyze, discuss and determine the goals and learning tasks. - Propose research questions/ research problems in the integrated topic. – Collect and analyze data and then combine knowledge of different subjects to complete the tasks of the project. - Propose solutions and then select the most appropriate solution to deal with problems in the integrated topic. - Make project plan.

Activity 2. Perform project tasks and complete the project (within a week)

Teacher's activities	Students' activities	Indications of problem-solving capacity development
<ul style="list-style-type: none"> - T observes and controls the procedure of the projects. - T consults, and supports when necessary. T may give some suggestions on generating and answering the research questions - T asks the group leaders to report the project's procedure and findings. T elicits feedback for the groups to complete the project if necessary. 	<ul style="list-style-type: none"> - The group members implement solutions proposed in the project and assign tasks, contact and ask for help from the T and other members when necessary. - Group members continuously contact and report the research findings to the group leader. - The group leader holds group discussions; collect, select, analyze and classify the data in tables and diagrams. - The group leader and other group members prepare for the presentation of the project findings (with images and illustrations). 	<ul style="list-style-type: none"> - Collect data with the use of different methods. - Analyze and present the research findings in the forms of tables, graphs and diagrams. - Complete the proposed plan successfully. - Coordinate with the presenters to give a full account of the project.

Activity 3: Report the project findings (25 - 30 minutes)

Teacher's activities	Students' activities	Indications of problem-solving capacity development
<ul style="list-style-type: none"> - T organizes and instructs the student groups to report their project findings (7-10 minute presentation for each group) - T can help Ss to analyze the research problems and the understand meaning of the project by asking some additional questions. - T acts as the judge in the Ss' discussions and gives the final comments. 	<ul style="list-style-type: none"> - The representative of each group presents the research findings and the product of the project. Other Ss listen, observe and discuss. - Group members work together to present and support the presentation of the project. - Members of other groups ask questions and give feedback. - Group members answer questions from other groups, specify the content and also raise questions for other groups. - A group member records all the questions and ideas. 	<ul style="list-style-type: none"> - Coordinate with group's members to present the research findings and the project products. - Answer questions from other groups and support to specify the project findings.

Activity 4: Evaluate students' problem-solving capacity (15- 20 minutes)

Teacher's activities	Students' activities	Indications of problem-solving capacity development
<ul style="list-style-type: none"> - T asks the Ss to proofread, edit and complete the project report. - T asks Ss to complete the Self-evaluation of their project and evaluation form of their problem-solving capacity development. - T asks Ss to revise and prepare for the next study. 	<ul style="list-style-type: none"> - Ss proofread, edit and complete the project report. - The groups conduct peer review, self-evaluation of their project results and self evaluation on the problem of their problem-solving capacity. - Ss revise, make mind maps and synthesize the knowledge about water in their own way. (homework). 	<ul style="list-style-type: none"> - Conduct self evaluation and peer evaluation on their project results and their problem-solving capacity development. - Apply the gained knowledge to solve the problems in the real life.

2.2.3. The Evaluation of the Development of Problem-Solving Capacity by the Teaching of Integrated Natural Science for Students in Secondary Schools

The Teaching Experiment Method

In each school of research, we select two classes in the same grade (grade 8 or grade 9): Experimental Group and Controlled Group. The pair of Experimental Group (EG) and Controlled Group (EG) is selected based on the same criteria, so they are considered to have the same starting point (the same learning outcomes). Therefore, to investigate the effects of the solutions, we designed tests on Experimental Group and Controlled Group. The details of teaching experiments are illustrated in Table 4.

Table 4. Teaching Experiment Method

Groups	Effects	Tests
Experimental Group	X	O1
Controlled Group	---	O2

To carry out teaching experiments, we followed the steps below:

Step 1: Discuss with the teacher in charge about the teaching content, methods, time and procedure of teaching experiments

- *For Experimental Group:* Teacher follows the proposed teaching plan of integrated topics collected from

combining subjects of natural science

- *For Controlled Group:* Teacher follows the existing teaching plan suggested by Ministry of Education and Training.

Step 2: Conduct teaching activities to the Experimental Group and Controlled Group. After each topic, we discuss with the teachers in charge and student participants to draw on experience, to make some changes on the content and the teaching plan of integrated topics for a greater success of the next teaching experiments.

Step 3: Collect and analyze data

During teaching experiments, we conducted a 45-minute test after finishing each integrated topic. These tests follow the same rules: taken from the same set of tests, have the same marking scale, and conducted in Experimental Group and Controlled Group of the same teacher. We also combined the tests with other forms of assessment in the proposed toolkit to evaluate students' problem-solving capacity by the teaching of integrated natural science in secondary schools [16].

Research results on the development of students' problem-solving capacity through the teaching of integrated natural science in secondary schools:

a) *Results from observation checklist*

Having collected data on the development of students' problem-solving capacity through teacher's observation checklist, we conducted a data analysis. In each criterion (from Criterion 1 to Criterion 10), we conducted a survey

on the students' levels of achievement in the set of evaluation criteria for both Experimental Group and Controlled Group. We then determined the standard deviation, the difference of the means between the Experimental Group and Controlled Group, and make a comparison of these means by using T-test, to determine whether or not the difference in the mean in each criterion for the Experimental Group and Controlled Group is statistically significant.

Below are the results of the Criterion 1 based on the data collected from the observation checklist (Table 5 and Table 6).

Table 5 shows that the standard deviation of the Experimental Group (1.47) is lower than that of Controlled Group (1.92). This means that the distribution of learning outcomes around the mean of Experimental Group is smaller than that of Controlled Group. In other words, the learning outcomes of the Experimental Group are more equal than those of Controlled Group.

According to Table 6, the paired difference of means of Experimental Group and Controlled Group is $0.80 > 0$,

and $\text{Sig. (2-tailed)} = 0.001 < 0.05$, hence, it can be concluded that the results achieved in the Criterion 1 of Experimental Group are higher than those of Controlled Group.

Similarly, we conducted analysis of the collected data for the other criteria for Experimental Group and Controlled Group in each grade with 2 rounds of experiments. Next, we compared the means of the total criteria for Experimental Group and Controlled Group. The final results are presented in Table 7, Table 8, Table 9 and Table 10.

Table 5. Standard deviation of students' achievement in Criterion 1 for Experimental Group and Controlled Group

		Statistics	
		Criterion1 – EG	Criterion 1- CG
N	Valid	250	245
	Missing	0	5
Std. Deviation		1.47354	1.92425
Variance		2.171	3.703

Table 6. Comparison of the means in Criterion 1 for Experimental Group and Controlled Group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Criterion 1- Experimental Group Criterion 1- Controlled Group	.80408	2.39757	.15318	.50237	1.10580	5.249	244	.001

Table 7. Summary of results in the criteria on the evaluation of students' problem-solving capacity through data collected from observation checklist – Grade 8 (EG: 250 students; CG: 245 students)

Criteria of evaluation	Levels of students' achievement						Std deviation		Difference of means (EG – CG)	T-test (Sig.)
	Level 1		Level 2		Level 3		EG	CG		
	EG	CG	EG	CG	EG	CG				
1	72	62	148	108	30	75	1.47	1.92	0.80	0.001
2	66	50	149	113	35	82	1.63	1.85	0.73	0.012
3	84	60	149	124	17	61	1.55	1.91	0.83	0.000
4	69	58	152	122	29	65	1.67	1.79	0.43	0.005
5	75	56	125	125	50	64	1.70	1.84	0.59	0.001
6	79	64	128	106	43	75	1.95	2.12	0.49	0.008
7	78	49	135	117	37	79	1.80	2.00	0.76	0.001
8	69	60	140	122	41	63	1.75	1.89	0.41	0.018
9	50	37	125	98	75	110	1.78	1.94	0.68	0.002
10	82	62	152	129	16	54	1.54	1.77	0.74	0.002

Table 8. Comparison of the mean values of criteria on the evaluation of students' problem-solving capacity through data collected from the observation checklist - Grade 8

		Mean	Std. Deviation	Difference of Means (EG – CG)	(Sig.)	ES
Groups	EG	6.50	0.56			
	CG	5.80	0.81	0.65	0.0015	0.8

Table 9. Summary of results in the criteria on the evaluation of students' problem-solving capacity through data collected from observation checklist – Grade 9 (EG: 280 students; CG: 275 students)

Criteria of Evaluation	Levels of students' achievement						Std Deviation		Difference of means (EG – CG)	T-test (Sig.)
	Level 1		Level 2		Level 3					
	EG	CG	EG	CG	EG	CG	EG	CG		
1	85	37	149	142	46	96	1.61	1.92	0.90	0.002
2	75	49	169	138	36	88	1.58	1.8	0.79	0.004
3	97	60	163	151	20	64	1.55	1.80	0.89	0.001
4	83	65	172	137	25	73	1.54	1.81	0.60	0.001
5	81	62	160	140	39	73	1.64	1.85	0.57	0.000
6	92	70	143	122	45	83	1.90	2.00	0.53	0.002
7	89	59	149	135	37	86	1.77	2.00	0.82	0.001
8	79	71	169	140	32	64	1.65	1.88	0.51	0.001
9	95	58	147	126	38	91	1.82	1.95	0.72	0.000
10	85	62	158	129	37	84	1.79	2.02	0.82	0.005

Table 10. Comparison of the mean values of criteria on the evaluation of students' problem-solving capacity through data collected from the observation checklist - Grade 9

		Mean	Std. Deviation	Difference of means (EG – CG)	(Sig.)	ES
Groups	EG	6.55	0.55	0.72	0.001	0.85
	CG	5.83	0.84			

As can be seen in Table 7 and Table 8, in each criterion (1-10): the standard deviation of Experimental Group is smaller than that of Controlled Group, the difference of means between the two groups is >0 and Sig. is < 0.05 . Hence, it can be said that the results achieved in each criterion of the Experimental Group are higher than those of Controlled Group. The biggest differences between these group can be found in the Criterion 1 (Identify the learning goals and learning tasks), Criterion 3 (Collect and combine knowledge of different subjects to solve the problem), Criterion 7 (Complete the project and report project findings) and Criterion 10 (Adjust and apply gained knowledge into father studies). This can be explained by the fact that during the learning process, the Experimental Group often organized some activities to deal with the problem in combination with the practice. In some modules, students of this group conducted group work to determine the learning goals, learning tasks and then collect and combine gained knowledge of different subjects to solve the problem, prepare and report research

findings. On the other hand, students, after finishing the project, are assigned the similar or new learning tasks so that they can apply the gained knowledge for further studies.

Besides, the results in Table 8 and Table 10 show that the difference of means of Experimental Group and Controlled Group is > 0 , and Sig. is < 0.05 . This means that this difference is statistically significant. Furthermore, the standard deviation of Experimental Group is lower than that of Controlled Group, indicating that the learning outcomes of Experimental Group are more equal than those of Controlled Group. As a result, it can be concluded that results about the development of problem-solving capacity for Experimental Group are higher those of Controlled Group. The ES on the two grades is about $0.8 \leq ES \leq 1.0$, which reveals that the solution shows its effectiveness.

b) Test results

Having collected data on the test results, we analyzed the data and then presented the results on the statistical parameters of the test in Table 11 and Table 12.

Table 11. Statistical parameters of tests for Grade 8

Grade 8	Statistical parameters						
	Mean	Median	Mode	Std. Deviation	Difference of means (EG - CG)	(Sig.)	ES
EG	7.34	7	7	1.57	1.35	0.002	0.82
CG	5.99	6	6	1.66			

Table 12. Statistical parameters of tests for Grade 9

Grade 9	Statistical parameters						
	Mean	Median	Mode	Std. Deviation	Difference of means (EG - CG)	(Sig.)	ES
EG	7.09	7	7	1.47	1.26	0.005	0.8
CG	5.83	6	6	1.58			

Comments: As can be seen in Table 11 and Table 12, it can be seen that the difference of means between Experimental and Controlled Group is > 0 , Sig. is < 0.05 , which indicates that the difference of means is statistically significant. Moreover, the standard deviation of the Experimental Group is smaller than that of the Controlled Group. As a result, it can be concluded that the test results of the Experimental Group are higher than those of the Controlled Group, or that the solution suggested has shown its effectiveness. The ES is determined through tests for grade 8 and 9 are 0.82 and 0.80, respectively, indicating that the solution shows a positive influence during teaching experiments.

3. Conclusion

After the analysis of the data collected from teaching experiments the findings reveal that the teaching of integrated natural science helps improve problem-solving skills for students in secondary schools. The application of the integrated natural science teaching in Vietnam is now increasingly significant and meaningful. Integrated teachings enables students to develop their ability in combining knowledge and skills learnt from different subjects (Physics, Chemistry, Biology and Geography) or any other aspects of learning to complete their learning tasks and to deal with problems arisen in the real life. As a result, students can learn how to adapt to considerable changes of the society and to meet the labor demands for the country's integration and modernization.

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