

Developing Criteria for Assessing Students' Collaborative Capability In Teaching Physics At High-School Level

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ABSTRACT:- Collaborative Capability is an essential skill for every individual in the modern society. Therefore, fostering students' capabilities in general and Collaborative Capability in particular is one of the core objectives of the Education Program constructed by Vietnam's Ministry of Education and Training (MOET) since 2018 [1]. In this paper, we presented the results of our research on the Assessment Criteria for students' Collaborative Capability and an experimental study using the proposed Assessment Criteria. The experiment in the experimental study was conducted on a sample of 165 students in 11th grade of Phan Chau Trinh – Danang High School, during the Optical Physics course in the academic year 2017-2018.

Key words:- Collaborative Capability, experimental study, Geometrical Optics, Assesment criteria, Teaching method.

I. INTRODUCTION

Given the ongoing trend of integration and globalization, collaboration is a crucial success factor in a working environment [2]. People are, in fact, increasingly aware of the benefit of cooperation in all social activities. The value of collaboration lies in the fact that it enables people to solve the tasks that they cannot solve individually [3]. Through collaboration, people become more interconnected, empathetic, and develop mutual understanding as well as a sense of responsibility in solving their common tasks [3]. However, in order to successfully engage in collaboration, each individual must possess a certain level of Collaborative Capability (CC). As CC is considered one of the most important capabilities of people in today's modern society, it is necessary to foster the CC of students through teaching since they attend high school [4].

In order to foster and develop CC for students, it is necessary to put them in practice, i.e., through collaborative learning. According to P. Phuong, collaborative learning is one of the earliest open teaching methods in the history.

Since the eighteenth century, in capitalist countries, the theory of collaborative learning has been studied and applied in high school teaching method. As cited in [5], the author emphasized the role of collaborative learning when declaring the school's main goal was to educate students to become people who know how to cooperate with others. They have been working to promote the use of student-to-student collaborations. Since 1980, research by Brown and Palincsar, along with other works of Slavin in 1994 and Renkl in 1995, have emphasized the important role of cooperation in life [2], [6].

In Vietnam, literature on the development of students' capabilities through teaching physics are reported by many researchers such as Pham Xuan Que and Thai Duy Tuyen [7]. Besides, the studies of other researchers such as Do Huong Tra, Le Van Giao and Luong Viet Thai also follow the capability approach, in which the authors studied specialized capabilities such as problem-solving capability and CC [3], [8], [9].

To the best of our knowledge, there are few studies focusing on the assessment of students' capabilities in teaching, especially the assessment of CC through teaching in high school. Therefore, in this paper, we presented the development and application of the Assessment Criteria for assessing student's CC in teaching physics at high schools. The work is experimentally studied at a high school in Da Nang City, Vietnam. The details are presented in the next sections.

II. DEVELOPMENT OF STUDENTS' CC THROUGH TEACHING PHYSICS

2.1. Collaborative capability

According to [10], capability is the learned or available skills of individuals to address identified situations, as well as the readiness and ability to find effective ways to solve problems in flexible situations.

According to [4], the concept of collaboration is understood as the process of social interaction, in which individuals work together, support and help each other in certain works to achieve common goals.

Thus, CC is the ability of individuals to share responsibilities, commit and know how to work together, listen, understand and care for each other, in order to promote the strength of each member in a job, certain areas for a common purpose.

2.2. Structure of CC

In order to develop students' capabilities, particularly the CC, it is necessary to clearly define the components of students' CC. According to training materials Guidance on teaching and testing in the direction of developing capability of high school students, capabilities can be categorized into one of the four groups: professional capability, methodology capability, social capability, individual capability - corresponding to the four pillars of education of UNESCO: Learn to know, learn to do, learn to live together, and learn to assert themselves [1]. In particular, together with communication capability, CC belongs to the group of social capability.

Students' CC can be evaluated through group activities, during which students are encouraged to show their collaborative skills. Therefore, it is necessary to point out the collaborative skills and behavioral indicators of each skill [11],[12].

2.2.1. Components of students' CC

Skill	Behavior Index
Evaluation and self-evaluation skill	Be able to self-assess the collaboration process of oneself
	Evaluate other members in the group and in other groups in the class
Teamwork skill	Be able to move in and assemble a group
	Take on different roles in the group
	Be able to pay attention during group work
	Determine how to collaborate and complete assigned tasks
Collaboration skills	Have collaborative and constructive attitude
	Know how to share and assist each other
	Engage in calm and amicable debates
Self-expression skills	Be able to present personal opinions and group reports
Listening and empathizing skill	Listen to other people's opinions
	Empathize and support other members
Conflict management and trust building skill	Be able to restrain oneself
	Be able to detect and resolve conflicts
Report writing skills	Summarize, select and arrange the opinions of team members to write final reports

2.2.2. Evaluation criteria for CC assessment

Based on the skills that need to be achieved in the process of teaching and developing CC for students and behavioral indicators corresponding to each skill, we have developed a set of evaluation criteria for CC assessment. This assessment framework consists of four levels from 1 to 4, in which Level 1 indicates the lowest CC and Level 4 indicates the highest CC.

Table 1: Criteria to evaluate CC

Criteria	Levels			
	Level 1	Level 2	Level 3	Level 4
Evaluation and self-evaluation skill	<ul style="list-style-type: none"> - Can not evaluate one's own ability in group discussion and activities. - Can not evaluate the ability of other members in group discussion and activities. 	<ul style="list-style-type: none"> - Inaccurately evaluate one's own ability in group discussion and activities. - Inaccurately evaluate the ability of other members in group discussion and activities. 	<ul style="list-style-type: none"> - Accurately but not confidently evaluate one's own ability in group discussion and activities. - Evaluate the ability of other members in group discussion and activities with moderate accuracy. 	<ul style="list-style-type: none"> - Accurately and confidently evaluate one's own ability in group discussion and activities. - Accurately evaluate the ability of other members in group discussion and activities.
Teamwork skill	<ul style="list-style-type: none"> - Can not move in and assemble a group. - Pay no attention - Can not identify the tasks needed to be done - Do not complete the assigned work. 	<ul style="list-style-type: none"> - Move in slowly and can not assemble a group. - Pay some attention but still show sign of distraction, can take on some simple tasks. - Identify the tasks needed to be done but do not carry them out in the correct time order. - Partially complete the assigned work. 	<ul style="list-style-type: none"> - Slowly and clumsily move in and assemble a group. - Pay attention and take on some specialized tasks. - Identify the tasks needed to be done and carry them out in relatively correct time order, with some hesitation. - Complete assigned work slowly. 	<ul style="list-style-type: none"> - Quickly move in and assemble a group in less than 1 minute. - Pay high attention and can take charge of all group tasks. - Identify the tasks needed to be done and carry them out in correct time order. - Complete assigned work quickly and accurately.
Collaboration skills	<ul style="list-style-type: none"> - Do not participate in group discussion. - Do not collaborate with other members - Do not take responsibility in the groupwork. 	<ul style="list-style-type: none"> - Infrequently participate in group discussion. - Discretely collaborate with other members, do not have full understanding of the group work - Show low sense of responsibility 	<ul style="list-style-type: none"> - Participate in group discussion without enthusiasm. - Collaborate with group members relatively well - Show a reasonable sense of responsibility 	<ul style="list-style-type: none"> - Participate in group discussion with enthusiasm, contribute with new and creative inputs. - Collaborate very well with group members. - Show a high sense of responsibility
Skill to express personal opinions	<ul style="list-style-type: none"> - Can not express their own opinions. 	<ul style="list-style-type: none"> - Can express their own opinions but unfluently. 	<ul style="list-style-type: none"> - Can express their own opinions fluently but not convincingly. 	<ul style="list-style-type: none"> - Can express their own opinions fluently and convincingly.
Listening and empathizing skill	<ul style="list-style-type: none"> - Do not listen to other people's opinion. - Do not empathize and assist other members. 	<ul style="list-style-type: none"> - Listen to people's opinions passively, do not give any feedbacks - Empathize and assist others in a few tasks but with neglect. 	<ul style="list-style-type: none"> - Listen to people's opinions and give feedbacks but with low accuracy. - Empathize and assist others in all the tasks but undedicately. 	<ul style="list-style-type: none"> - Listen to people's opinions and give accurate and valuable feedbacks. - Enthusiastically and dedicatedly empathize and assist other members in all the tasks.

Conflict management and trust building skill	- Do not discuss, accept and agree with others' opinions if that opinion do not match their own opinions. - Do not encourage other members to join group work; do personal activities during group work.	- Discuss but do not compromise or agree with others' opinions. -Encourage people in group work but with neglect, occasionally do personal activities.	- Discuss, compromise and agree with others' opinions unwillingly. - Encourage other members to participate in group work appropriately.	- Discuss, compromise and agree with others' opinions positively. - Enthusiastically encourage people to participate in the team-working task.
Report writing skills	- Can not synthesize, select and arrange group members' opinions to write a final report.	- Can synthesize but can not select and arrange group members' opinions to write a final report.	- Can synthesize, select and arrange group members' opinions to write a final reportbut without a logical structure.	- Can accurately and reasonably synthesize, select and arrange group members' opinions; can write the report with a logical and scientifically proper structure.

The rating scale:

Level 1: 0.25 points; Level 2: 0.5 points; Level 3: 0.75 points; Level 4: 1 point

Adding up the points of all 7 criteria will yield a total score of X.

If $X < 2$: CC level is Low

If $2 \leq X < 4$: CC level is Average

If $4 \leq X \leq 5,5$: CC level is Above Average

If $X > 5,5$: CC level is High

Based on the objective of the Physics Optical 11 course for highschool level and the objective of fostering CC for students, we have designed a checklist of students' attitudes and skills during implementing experiments in groups.

III. FINDINGS AND CONCLUSION

Based on the standard of knowledge, skills and attitudes in Vietnam's contemporary educational program, we have designed the teaching process and organized the teaching activities with orientation towards the development of CC for the students in the Optical Physics 11 course, high school level, with the following knowledge units: Lesson 26: Light refraction, Lesson 31: Total internal reflection, Lesson 35: The eyes. After that, we also used the proposed set of criteria to assess the development of students' CC as well as the effectiveness of the teaching process in terms of developing the CC for students.

3.1. Experimental results and discussion

3.1.1. The process

After being built, the set of criteria for evaluating CC was corrected and completed after consulting with some high school teachers and experts. Next, the set of criteria was used to assess the students' CC in the pedagogical experiment.

The pedagogical experiment was conducted in 4 classes of Phan Chau Trinh High School in Da Nang city. The lectures involved in the experiment were part of the Optical Physics course for 11th grade (high school level). The goal is to train and evaluate students' CC during teaching, and at the same time to evaluate the effectiveness of the teaching process oriented towards developing CC for students.

The total number of students participating in this pedagogical experiment was 165 students from four 11-grade classes. They were divided into two groups: two classes belong to the control group and two classes belong to an experimental group. The chosen students in the sample were comparable in terms of competencies, according to the Physics exam results at the beginning of semester II and the average Physics score of the four classes in semester I.

We evaluated the CC of students through questionnaires, attitudes and skills checklist table in group activities; and evaluated the effectiveness of the teaching process towards developing CC. After having collected, treated and analyzed the data, we came to some conclusions as follows.

3.1.2. Experimental results

In order to know whether the teaching activities oriented towards developing the CC for students (according to the proposed process) is effective or not, we have closely monitored and observed the students' activities and evaluated students according to the proposed criteria. After that, we also conducted a statistical analysis of the students' test results after the pedagogical experiment.

- Qualitative assessment

All the activities of teachers and students during the lesson are observed according to the proposed criteria in table 1. After each lesson, there was a discussion between teachers and students to collect feedbacks and draw experiences for future lessons as well as for the research topic. Consequently, the following comments can be made:

In control classes, there were few conducted experiments. The teaching method has been innovated but has not shown a substantial improvement. Teachers were the main speakers and students only focused on listening and taking notes. Although students have answered questions posed by teachers, they have not been proactively and excited.

For the experimental classes, most activities of teachers and students were active. The lecturing time has been shortened and the number of collaborative activities has been improved. The experiments, visual aids (images, videos) and suggestive questions made students interested in learning activities. Students cooperated very enthusiastically in group activities. The quantity and quality of the answers given by students were much higher than those of the control classes. Students' CC have been improved through each lesson and this was expressed clearly through carrying out the learning tasks given by the teachers. In the first lesson, teachers observed that in general students were still hesitating to collaborate with others upon receiving the tasks from the teachers. However, in the following lessons, students became more proactive in assigning tasks, moved quickly into groups and knew how to collaborate with team members. They also reached consensus faster and were able to express ideas with other members. The collaboration took place with mutual trust. The team members exchanged ideas, agreed on and accepted other members's opinions in a more amicable and effective way. Eventually, the results of the group work were improved. Most students not only knew how to collaborate but also shared work as well as had a sense of responsibility when solving the tasks given by teachers.

- Quantitative assessment

On the basis of monitoring and observing the activities of groups of 5 students in each lesson, the teachers have randomly selected 3 groups of students per class to conduct a review and evaluation of the development of CC based on the proposed criteria. The results are shown in Table 2.

Table 2: Accumulative points of students' CC in the experimental classes

Lesson	The number and percentage of students by CC points							
	X < 2		2 ≤ X < 4		4 ≤ X ≤ 5,5		X > 5,5	
	Nº	%	Nº	%	Nº	%	Nº	%
26	3	10,0	10	33,3	10	33,3	7	23,3
31	2	6,7	7	23,3	12	40,0	9	30,0
35	2	6,7	6	20,0	13	43,3	9	30,0

The above table shows that the number of students reaching a point of $4 \leq X \leq 5.5$ and $X > 5.5$ increased significantly in the later lessons. In terms of CC levels, this shows that the number of students who achieved Above average and High level of CC increased significantly in Lesson 31 and 35. Combining the above summarized results with the results of the survey of students' CC after pedagogical experiment, we can see that:

- The CC of students clearly improved through each lesson and can be seen through their applying the collaborative skills to solve the problems and tasks given by the teachers.
- In addition, we also gave students a test to test their knowledge about the 2 chapters "Light refraction" and "Eyes and optical devices". The following table shows the score of students in the experimental and control classes [7].

Table 3: The number of tests achieved a point of X_i

Class	Number of students	THE NUMBER OF TESTS RECEIVED X_i SCORE											X_i
		0	1	2	3	4	5	6	7	8	9	10	
Control	83	1	0	2	12	12	17	14	11	8	4	2	Number of tests
Experimental	82	0	1	1	5	9	16	15	14	10	7	4	

We also analyzed, calculated and summarized the statistical parameters from the test points as follows:

Table 4: Summary of statistical parameters

Class	Number of students	Average score (\bar{X})	S^2	S	$V(\%)$	$X = \bar{X} \pm m$
Control	83	5,5	1,2	1,09	19,8	$5,5 \pm 0,013$
Experimental	82	6,2	1,4	1,18	19,0	$6,2 \pm 0,014$

As can be seen from the above table, the average test score of the experimental class is higher than that of the control class. The value of the standard deviation is low, which indicates that the obtained data is less dispersed. Thus, the average value is highly reliable. This also means that the process we proposed is more effective than the conventional teaching process. The teaching activities oriented towards developing CC for students, through the use of experiments in Optical Physics 11, has contributed to the improvement of students' proactiveness and flexibility in solving problems.

IV. CONCLUSIONS

Teaching activity with a capability approach is considered important in preparing the future citizens given the current trend of integration and globalization. Each individual's life is always connected with the community and society, where every interpersonal relationship exists. Therefore, in teaching, it is necessary to focus on fostering general capability and CC in particular for students in order to prepare to a well-trained human resources to facilitate the needs of the country for sustainable future growth.

In order to assess the level of students' CC, it is necessary to have a defined set of appropriate tools for measuring capability. In this study, we have developed a set of criteria for evaluating the CC of students and applied them to assess the development of students' CC through teaching activities during the Optical Physics 11 course. The results of the pedagogical experiment confirmed the feasibility of the set of criteria to assess students' CC in teaching physics in high school.

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