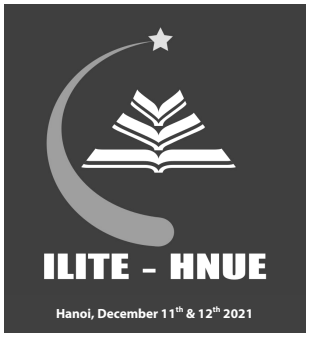
INNOVATION FOR SUSTAINABLE EDUCATION IN THE CHANGING CONTEXT

Proceedings of the 2nd International Conference on Innovation in Learning Instruction and Teacher Education – ILITE 2



ĐỔI MỚI SÁNG TẠO TRONG DẠY HỌC VÀ ĐÀO TẠO GIÁO VIÊN

Chủ đề: Đổi mới sáng tạo vì sự phát triển bền vững của giáo dục trong bối cảnh nhiều biến đổi

NHÀ XUẤT BẢN ĐẠI HỌC SƯ PHẠM

TABLE OF CONTENT

ENHANCING THE TEACHING COMPETENCE IN BIOLOGY EXPERIMENTAL PRACTICAL LESSONS IN HIGH SCHOOL FOR PEDAGOGICAL STUDENTS

Phan Duc Duy[1], Pham Thi Phuong Anh[1]*,
Dang Thi Da Thuy[1], Nguyen Thi Dieu Phuong[1], Le Minh Duc[2]

Abstract: *The general education program for Biology 2018 is oriented to develop learners' qualities and competencies. In this new educational program, the Biology competencies were identified, including three core competencies: the cognition of Biology, the exploration of the living world, and the application of learned knowledge and skills. To form these competencies, the methods of teaching have to be changed significantly. Biological sciences belong to the field of experimental science, therefore, using experiments to study in the classes and the labs is a typical method in teaching to form biology competencies for students. By implementing experiment activities, students perceive Biology sciences, explore the natural world and develop the ability to apply knowledge to real life. The research to enhance the teaching competence in Biology experimental practical lessons in high school for pedagogical students is necessary to meet the requirements to educational renovation. In this research, the theoretical method and pedagogical experimental method were used. Based on the theoretical method, the structure of the pedagogical students' competences in teaching experimental practices in Biology lessons was identified. In which, it includes three core components: competence to design these lessons, competence to conduct the teaching activities of these lessons, and competence to assess students in these lessons. From there, we suggested measures to improve their competences in teaching these lessons. The results of pedagogical experiments showed that the proposed measures were effective and met the requirements of developing teaching competency for Biology pedagogical students, who are the future Biology teachers.*

Keywords: *experimental practices, pedagogical competence, teaching competence, Biology experimental practical lessons, teaching skills*

INTRODUCTION

The general education program 2018 is oriented to form and develop the qualities and competencies of students. In which, "focusing on practicing, applying learned knowledge and skills to solve problems in study and life" (MOET, 2018, p. 5). "Natural science education has the mission of forming and developing the scientific worldview in students; plays a key role in educating students the spirit of objectivity, the love of nature, and the respect of the laws of nature, so that they can behave with nature by the requirements of sustainable social development and environment. Natural science education helps students gradually form and develop natural science competencies through observation and experimentation, apply a combination of knowledge and skills to solve problems in life" (MOET, 2018, p. 19-20). Biology is one of the natural sciences and is also the experimental science. Therefore, "experiment is a method of biological research, and also a typical teaching method of this subject. Through the organization of experimental and practical activities, Biology helps students explore the natural world, develop the ability to apply knowledge into practice and the ability to orientate their careers after general education" (MOET, 2018, p. 3). Experimental

* Corresponding Author: Pham Thi Phuong Anh; E-mail Address: ptpanh@hueuni.edu.vn
[1] University of Education, Hue University, Vietnam
[2] Sai Gon University, Vietnam

practice is the implementation of experiments in practical lessons. Through doing and observing experiments, learners identify the nature of Biology phenomena and processes. From there, they find the principles of Biology. By experimental practical activities, "students themselves can discover new things from their intentional impacts on experimental subjects. Consequently, students stimulate their interests in learning, create their passion and confidence, and the love of science. They also recognize the role of humans in conquering and renovating nature" (Dinh, 2001).

To renovate education, teachers and pedagogical students are the first forces that need to be trained and fostered to improve their competencies to meet the requirements of the new educational program. The competence of Biology teachers to teach and practice experiments is one of the significant teaching competences. However, our survey showed that Biology teachers in high schools today still face many difficulties and they were confused in designing and organizing Biology experimental practical lessons. Therefore, the research of measures to improve this competence in Biology is an urgent issue in education in Vietnam today. This research helps to timely meet and be appropriate with the goals of the general educational program 2018.

CONTENT

1. The competence in teaching experimental practical lessons

1.1. The concept of competence in teaching experimental practical lessons

Both the terms "competency" and "competence" are widely used nowadays. They have been studied in various fields. Therefore, it is necessary to distinguish these two terms in the researches. The review of the literature suggested that 'competency' and "competence" are two distinct approaches to studies in the human resource management field. The term "competency" is the person-oriented behavioral approach that refers to the behaviors or personal attributes supporting an area of work. The term 'competence' is a task-oriented functional approach that is used for describing an area of work tasks or job outputs (Wong, 2020). An example of the term "competency" can be seen in Woodruffe's research. In his research, he defined "a competency was as the set of behavior patterns that the incumbent needs to bring to a position to perform its tasks and functions with competence". (Woodruffe, 1993). While in the research of Gonczi and Hager, they showed a clear definition of the term "competence". In their research, they showed that there are several very different ways of thinking about competence, how competence is conceived will make a big difference to the ways competency standards are used and assessed. According to the integrated conception, "competence is conceptualized in terms of knowledge, abilities, skills, and attitudes displayed in the context of a carefully chosen set of realistic professional tasks which are of an appropriate level of generality" (Gonczi & Hager, 1996). In our research, we tend to use the term "competence" in the purpose of the task-oriented functional approach.

In the fields of vocational education in general and teacher training in particular, the term "pedagogical competence" is widely used. According to Rahman, "teachers' pedagogical competence is the ability to manage learning, which includes planning, implementation, and evaluation of learning outcomes of learners. These competencies should be owned by every teacher in order to achieve success in learning and teaching" (Rahman, 2014). La, in her research, defined "pedagogical competence" as a professional competence of a teacher, includes two components: teaching competence and educational competence. Teaching competence is the type of professional competence that teachers need in teaching activities. It is the combination of knowledge, skills, pedagogical attitudes, and personal experiences, which enable

teachers to effectively perform teaching tasks according to the set standards under certain conditions (La, 2019).

From the definition of pedagogical competence above, teaching competence can be seen as one of two parts of pedagogical competence. It is "the complex combinations of knowledge, skills, understanding, values, and attitudes, leading to effective action in the situation. Since teaching is much more than a task and involves values or assumptions concerning education, learning, and society, the concept of teacher competences may resonate differently in different national contexts" (EC, 2013, p. 8). Teaching competence is specifically manifested through four components of competences: competence to design teaching activities, competence to conduct teaching activities, competence to test and evaluate teaching activities, and competence to manage teaching activities. (Vu, 2016).

From the above studies, it can be seen that the teaching competence in experimental practical lessons is the set of knowledge, skills, pedagogical attitudes, and personal experiences, which enables teachers to successfully perform the experimental practical lessons. This should include planning the lessons, implementation of the lessons, and evaluation of learning outcomes of learners.

1.2. The structure of the teaching competence in Biology experimental practical lessons

Based on the studies of definitions of teaching competence above and the studies of structures of teaching competence according to Vu Xuan Hung (2016), the model of pedagogical competence of Olsson et al. (2010), the structure of the teaching competence in teaching experimental practical chemistry by Ly Huy Hoang (2018), and the teacher competences according to Estonian standards by Eisenschmid E. and Löfström E. (2014), a structural model of teaching competence in Biology experimental practical lessons was suggested in our research and it can be seen in Figure 1. In which, this competence is composed of three core components: competence to design these lessons, competence to implement the teaching activities of these lessons, and competence to assess students in these lessons. Each component competence is represented by elements. Based on the indicators of each element, in the process of training for pedagogical students, lecturers could assess the achieved levels of each component competence. From our research, the specific indicators of each component competence were studied and determined clearly in Tables 1, 2, and 3.

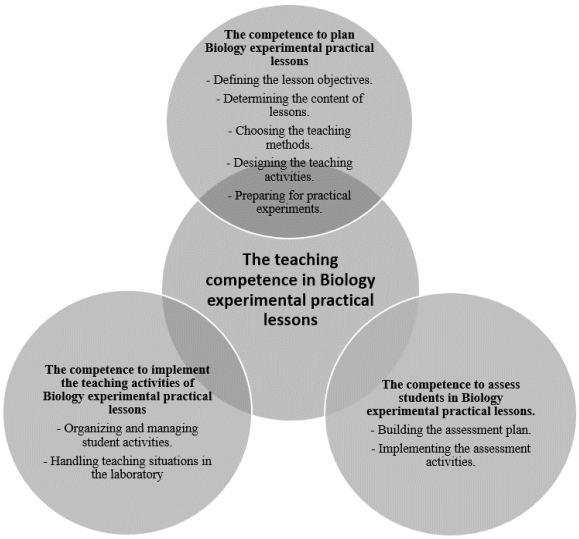


Figure 1. The structural model of the teaching competence in Biology experimental practical lessons (Authors' compilation)

1.3. The indicators of the teaching competence in Biology experimental practical lessons

From our research, the indicators of teaching competence in Biology experimental practical lessons were identified. The component competences that constitute this teaching competence had been concretized into elements with corresponding indicators in Table 1, Table 2, and Table 3.

In Table 1, the elements of the competence to plan Biology experimental practical lessons and their indicators are shown. They include: defining the lesson objectives, determining the content of lessons, choosing the teaching methods, designing the teaching activities, and preparing for practical experiments.

Table 1. The indicators of the competence to plan Biology experimental practical lessons

The elements of the competence to plan Biology experimental practical lessons	**Indicators**
1. Defining the lesson objectives	Identifying the teaching objectives to meet the requirements of the curriculum and be flexible with the actual teaching conditions.
2. Determining the content of lessons	Fully identifying the main teaching contents that the practical lessons are aimed at.
3. Choosing the teaching methods	– *Selecting suitable teaching methods which go along with teaching objectives and contents.* – *Coordinating flexible teaching methods to achieve teaching effectiveness.*
4. Designing the teaching activities	Designing teaching activities suitable to teaching contents and teaching conditions.
5. Preparing for practical experiments	– Preparing specimens and materials for experimental practices. – Using chemicals, facilities, and equipments for experimental practices. – Designing and conducting practical experiments in the lessons. – Anticipating teaching situations in the laboratory and suggest the appropriate measures.

In Table 2, the indicators of the competence to implement the teaching activities of Biology experimental practical lessons are identified. It includes two elements with their indicators: organizing and managing students' activities and handling teaching situations in the laboratory.

Table 2. The indicators of the competence to implement the teaching activities of Biology experimental practical lessons

The elements of the competence to implement the teaching activities of Biology experimental practical lessons	**Indicators**
1. Organizing and managing students' activities	– Performing the sample experiment correctly and accurately. – Guiding students to perform practical experiments correctly and safely. – Coordinating teaching methods flexibly and effectively. – Organizing teaching activities suitably to the conditions of the classroom. – Managing students during the experiment in the laboratory.
2. Handling teaching situations in the laboratory	– Taking appropriate measures to deal with situations of deviation in experimental results. – Taking appropriate actions for laboratory safety situations.

Table 3 shows the competence to assess students in Biology experimental practical lessons and their indicators, including two elements: building the assessment plan, and implementing the assessment activities.

Table 3. The indicators of the competence to assess students in Biology experimental practical lessons

The elements of the competence to assess students in Biology experimental practical lessons	**Indicators**
1. Building the assessment plan	– Determining the goal of assessing students' competencies through experimental practices. – Developing tools to assess students' competencies through experimental practices. – Designing activities to assess students' competencies through experimental practices.
2. Implementing the assessment activities	– Using tools to assess students' competencies through experimental practices. – Assessing students' competencies to perform practical experiments.

The identification of the indicators of component competences is significant to propose appropriate measures to improve the teaching competence in Biology experimental practices lessons. Based on these indicators, the measures to improve this teaching competence have been suggested and applied in the teaching process for Biology pedagogical students.

2. The measures to improve the teaching competence in Biology experimental practices lessons for pedagogical students

Based on the structural model of teaching competence in experimental practices in Biology lessons (Figure 1) and its indicators in Tables 1, 2, and 3, seven key measures are proposed to improve teaching competence in Biology experimental practical lessons for pedagogical students as follows:

2.1. Guide students to analyze the content of Biology experimental practical lessons in textbooks to determine teaching objectives, contents, and methods, thereby design teaching activities

The identification of teaching objectives, contents, and methods is the basis for designing lesson plans. Based on requirements of the curriculum and contents of textbooks and teaching theory, lecturers guide pedagogical students to discuss and practice building teaching objectives, determining teaching contents and teaching methods that are appropriate to the student's level. From there, they practice designing teaching activities for the experimental practices in Biology lessons. These measures should be taken in teaching the modules of the Methodology of Teaching Biology at the university.

2.2. Instruct students to study audiovisual media to learn how to conduct experiments and teach Biology experimental practical lessons

Lecturers should use the audiovisual media of practical experiments in general and Biology experimental practical lessons in particular in teaching at university. They should guide students to analyze how to design practical experiments and organize teaching activities. These audiovisual medias could be videos that are available on the internet or videos made by lecturers. Teachers guide students how to analyze sample videos, then ask students themselves to practice more.

Figure 2. Video of Practice observing the stages of mitosis on the red onion root microscopy specimens on YouTube (https://www.youtube.com/watch?v=Bm8kvYErbhw)

2.3. Instruct students in the preparation of specimens, materials, chemicals, and experimental equipment

To conduct Biology experiments, the preparation for experimental practices is an important required skill of Biology teachers. In the curriculums at the universities, pedagogical students in the Biology departments have done lots of experiments in specialized subjects. However, students rarely have opportunities to participate in experimental preparation. This job belongs to instructors or laboratory assistants. Therefore, students are often confused in preparation specimens, materials, chemicals, and equipments for experimental practice.

To practice this skill, students need to be guided to look for and make good specimens, and to use materials and chemicals in the right way. They also have to learn how to use popular practical equipment in biological experiments. Based on the content of the experiments, students learn to select the appropriate specimens, materials, chemicals, and equipment to conduct the experiments.

For example: To practice the experiment to observe the phases of mitosis on the red onion root specimen, students need to prepare the following specimens, chemicals, and equipments:

– Specimens: Red onion roots were immobilized in Carnoy solution to keep the cells from being damaged and the mitotic phases stable.

– Chemicals: Acetocarmine solution, acetic acid 45% solution.

– Experimental equipments: Optical microscope, microscopic glass slides, microscopic coverslips, blotting papers, needles, razor blades, scissors, alcohol lamps.

2.4. Propose measures to improve in practical experiments to be suitable to the actual conditions in the classroom

In most of the experimental practices, the textbook clearly shows how to conduct the experiments. However, from the implementation of practical experiments in class, sometimes teachers need to make flexible improvements to match the actual conditions and improve the effectiveness in teaching Biology experimental practical lessons.

Here are some measures we have tested for the practical experiment: Observing the phases of mitosis on red onion root specimens (Table 4).

Table 4. Some measures to improve the practical experiment: Observing the stages of mitosis on red onion root specimens

Improvements	Requirements	Difficulties	Measures
1. Specimens	Red onion roots (Allium ascalonicum L.)	Textbooks do not specify when to cut roots. If the roots are cut at the wrong stage, it is hard to observe cells in mitosis.	– Choose mature and dry onions and plant them in moist soil or moist cotton. The roots appear about 3-5 days before the experimental day. – When the roots grow about 1-2 centimeters, wash them and cut the root tips about 3-4 millimeters. After that, put and store the root tips in the Carnoy solution. Keep the roots stable for 12 hours, then wash and store them with the 70o alcohol solution.
2. Chemicals and experimental equipments	Acetocarmin dye	May not have this chemical	The acetocarmine dye could be replaced with methylene blue. The preparation of methylene blue dye is easy: mix 1% methylene blue solution in 10% acetic acid solution; filtered through filter paper and stored in colored vials in a cool place (the obtained result was showed in Figure 3).
3. Procedure	The experiment should be conducted in one class period (45 minutes).	It takes too long to make a temporary specimen according to the instructions in the textbook, in which the	It is possible to change the procedure of this experiment as follows: (the obtained result was showed in Figure 4) – Soak the roots in 1.5N HCl for about 5 minutes. This measure will make the root specimens moderately soft and be convenient for spreading cells evenly on the microscopic

Improvements	Requirements	Difficulties	Measures
		waiting time to soak the roots in the dye is 30-40 minutes.	glass slide. In this way, the success rate is high, and it just take a short time to execute. – Use a needle to take 3-5 roots and heat up the roots in 4-5% carmine dye solution until they are soft. – Wash the dyed roots with 45% acetic acid before making the microscopic specimens.

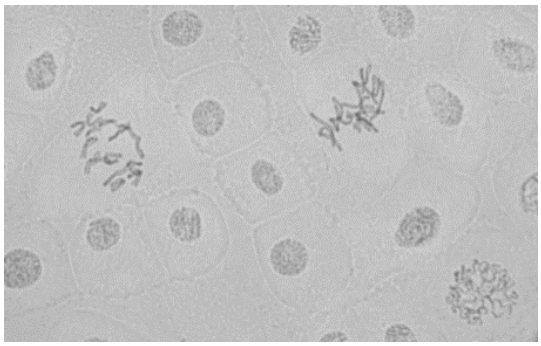


Figure 3. Mitosis stages on red onion root specimens stained with 1% methylene blue (400 times) under the optical microscope (Author's compilation)

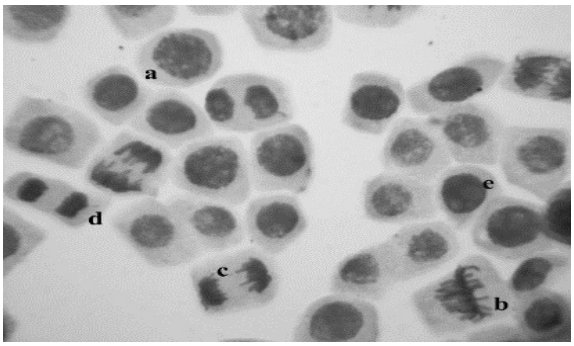


Figure 4. Mitosis stages on red onion root specimens stained with acetocarmine in an improved manner under the optical microscope (a. Prophase, b. Metaphase, c. Anaphase, d. Telophase, e. Interphase) (Author's compilation)

2.5. Use teaching cases to practice the students' skills of planning and handling situations that could happen in the laboratory

One of the difficulties for students and young teachers is that they do not have experience in handling situations that happen in teaching experimental practice in the laboratory. To deal with this problem, we use cases to train students on these skills. We have used two types of cases: cases of false results of experiments and cases of the rules of using the laboratory. From these cases, students have learned how to analyze the procedure of practical experiments to predict possible situations and suggest the appropriate handling measures for these situations.

For example, from the practical experiment of observing the stages of mitosis on red onion root specimens, we have predicted some possible situations and have suggested some suitable measures to handle them. They are shown in Table 5.

Table 5. Types of cases that may happen in teaching the experimental practical lesson of observing the phases of mitosis on red onion root specimens in the laboratory

Types of cases	Possible cases	Measures
Cases of false results of experiments and cases of the rules of using the laboratory	Air bubbles appear in microscopy slide specimens of the red onion roots.	Instruct students to place the coverslip close to the edge of the 45% acetic acid droplet and tilt it about 45°. Use a needle to support the coverslip and lower the foil slowly so that the water runs along its edge to avoid air bubbles.
	Students do not see onion red root cells under the microscope.	Recheck if students use the microscope correctly.
	Students see cells but do not find any stage of mitosis.	The students may use the root portion without the meristem. Instruct students to choose the darker red-dyed root. This part is the root tip with meristem.
	The specimens are damaged, due to high temperature or too long heating time, and mitosis is not observed (Figure 5).	Instruct students to pay attention to the time to heat up the roots and not to boil them.

Types of cases	Possible cases	Measures
Cases of the rules of using the laboratory	Students may break the coverslips by rubbing vigorously with a needle.	Use their index fingers to gently rub on the coverslips to spread the roots evenly.
	Students boil the carmine solution that may cause the droplet to come out.	Remind students to set the mouth of the experimental test tube toward no one and be careful not to let the acetocarmine solution boil.
	Dropping experimental equipment creates sharp shards.	Remind students to do experiments carefully. Prepare first aid measures in the laboratory.

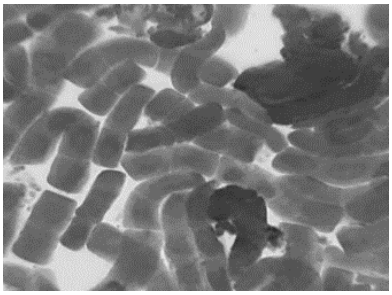
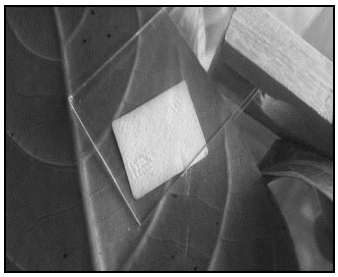


Figure 5. The microscopy slide specimen of red onion root cells damaged by overheating (Author's compilation)

2.6. Organize students to test the procedure of experiments in textbooks and improved experiments

To guide students to perform practical experiments in the laboratory, teachers need to conduct these experiments and verify the results before class to ensure the effectiveness and accuracy of the experiments. It also increases the confidence of teachers in experimental practical lessons. Therefore, we have instructed students to practice performing the experiments in the textbook and the improved experiments to suit the actual conditions of the laboratory at schools (Figure 6 and Figure 7).

Figure 6. Improved experiment to detect respiration in plants through CO_2 emissions (Author's compilation)



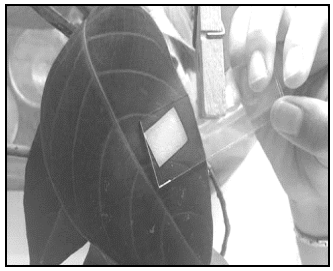


Figure 7. Experimental results for transpiration in leaves: a. Upper surface of leaf b. Underside of leaf (Author's compilation)

2.7. Practice teaching experimental practical lessons

The performance of experimental practical lessons has many differences compared to the theoretical classes. The laboratory often has various equipment, so it requires teachers to have the ability to organize teaching and manage the activities of students while they practice experiments. Teachers also have to know how to assess the competence of students to perform practical experiments. During the teaching practice, the pedagogical students could verify their teaching methods and measures to handle situations in the laboratory. By attending the pedagogical students' performances, lecturers can give feedback after classes. In this way, students can make appropriate adjustment to improve teaching effectiveness.

3. Research Methodology

3.1. Research question

If the structure of the Biology pedagogical students' competence in teaching practical experimental lessons can be determined and measures to improve their teaching skills in these lessons can be proposed, then this competence of Biology pedagogical students improves.

3.2. Sample

The study was done in two classes of fourth-year students in Biology Pedagogy Departments at two universities: The University of Education, Hue University in Thua Thien Hue province, and Saigon University in Ho Chi Minh City.

– Characteristics: Students have completed the modules of Teaching Theory and Teaching Methods.

– Sample size: The total number of students selected to experiment was 72 students, including 24 students in the University of Education, Hue University, and 48 students in Saigon University.

3.3. Procedure

To evaluate the effectiveness of measures to improve the pedagogical students' competences in teaching Biology experimental practices, we conducted a pedagogical experiment to determine the change of their core components of these competences.

Due to time constraints, we surveyed the needs of pedagogical students to choose two elements of the teaching competence in Biology experimental practical lessons to conduct the pedagogical experiment. They include preparing for practical experiments and handling teaching situations in the laboratory and can be seen in Table 6.

Table 6. The core elements of the competence of teaching experimental practical lessons selected for the pedagogical experiment

The elements of teaching competences	Indicators
1. Preparing for practical experiments	– Preparing specimens and materials for experimental practices. – Using chemicals, facilities, and equipments for experimental practices. – Designing and doing practical experiments in the lessons. – Anticipating teaching situations in the laboratory and suggesting the appropriate measures.
2. Handling teaching situations in the laboratory	– Taking appropriate measures to deal with situations of deviation in experimental results. – Taking appropriate actions for laboratory safety situations.

We designed a rubric to evaluate the elements of pedagogical students' competences in teaching experimental practical lessons through 6 indicators (skills) according to Table 6 at three timelines: before, during, and after the experiment. We chose five experimental practical lessons in the Biology curriculum in grades 10 and 11 to train pedagogical students and evaluate their teaching competences, including:

– Lesson 1: Practice experimenting with primary contraction and anti-contraction (Lesson 31, Basic Biology 10 Textbook, pages 51-52).

– Lesson 2: Practice some experiments on enzymes (Lesson 15, Basic Biology 10 Textbook, pages 60-62).

– Lesson 3: Practice observing the phases of mitosis on red onion root microscopy specimens (Lesson 31, Advanced Biology 10 Textbook, pages 105-106).

– Lesson 4: Practice detecting chlorophyll and carotenoids (Lesson 13, Basic Biology 11 Textbook, pages 56-58).

– Lesson 5: Practice detecting respiration in plants (Lesson 14, Basic Biology 11 Textbook, pages 59-60).

Experimental period: From September 2019 to December 2019.

4. Results

After the experiment, we processed statistics on the development of various teaching skills of pedagogical students in teaching Biology experimental practical lessons. The obtained results are shown in Table 7.

Table 7. Levels of pedagogical students' teaching skills across the experiment

The elements of teaching competences	Indicators	Levels	Pre-test	Mid-test	Post-test	Total variance
1. Preparing for practical experiments	Preparing specimens and materials for experimental practices.	Weak and poor	66.67	47.22	26.39	-40.28
		% variance	-19.45	-20.83		
		Pretty good and good	13.89	26.39	52.78	38.89
		% variance	12.5	26.39		
	Using chemicals, facilities, and equipments for experimental practices	Weak and poor	25	18.06	6.94	-18.06
		% variance	-6.94	-11.12		
		Pretty good and good	41.67	63.89	75	33.33
		% variance	22.22	11.11		
	Designing and doing practical experiments in the lessons	Weak and poor	37.5	12.5	6.94	-30.56
		% variance	-25	-5.56		
		Pretty good and good	25	52.78	61.11	36.11
		% variance	27.78	8.33		
	Anticipating teaching situations in the laboratory and suggesting the appropriate measures	Weak and poor	52.78	34.72	5.56	-47.22
		% variance	-18.06	-29.16		
		Pretty good and good	27.78	41.67	65.28	37.5
		% variance	13.89	23.61		
2. Handling teaching situations in the laboratory	Taking appropriate measures to deal with situations of deviation in experimental results	Weak and poor	58.33	30.56	15.28	-43.05
		% variance	-27.77	-15.28		
		Pretty good and good	20.83	41.67	58.33	37.5
		% variance	20.84	16.66		
	Taking appropriate actions for laboratory safety situations	Weak and poor	20.83	13.89	2.78	-18.05
		% variance	-6.94	-11.11		
		Pretty good and good	55.56	61.11	79.17	23.61
		% variance	5.55	18.06		

** Percent variance (% variance) is the difference in the percentage of each skill across the experiment.*

From Table 7, it can be seen that:

Before the experiment, the percentage of students with weak and poor skills accounted for the highest percentage in the skill of preparing specimens and materials for experimental practices (66.67%) and the lowest in the skill of taking appropriate actions for laboratory safety situations. The skills have a weak and poor percentage greater than 50% in the important skills in experimental teaching, including some skills: Preparing specimens and materials for experimental practices (66.67%), taking appropriate measures to deal with situations of deviation in experimental results (58.22%), and anticipating teaching situations in the laboratory and suggesting the appropriate measures (52.78%). The percentage of students with pretty good and good skills in most of the teaching skills accounted for less than 50%, only taking appropriate actions for laboratory safety situations accounted for more than 50% and reached the highest rate (55.56%). The skill with the lowest percentage of pretty good and good students is taking appropriate measures to deal with situations of deviation in experimental results (20.83%).

During and after the experiment, the percentage of students with weak and poor skills in all skills decreased significantly, and the percentage of students with good and good skills increased. In which, the skills that have been improved the most are: The skill of anticipating

teaching situations in the laboratory and suggest the appropriate measures (reduced by 47.22% in the rate of weak and poor levels and increased by 37.5% in the rate of pretty good and good levels), skills of taking appropriate measures to deal with situations of deviation in experimental results (reduced by 43.05% in the rate of weak and poor levels and increased by 37.5% in the rate of pretty good and good levels), and the skill of preparing specimens and materials for experimental practices (reduced by 40.28% in the rate of weak and poor levels and increased by 38.89% in the rate of pretty good and good levels). The skill that have been improved the least was the skill of taking appropriate actions for laboratory safety situations (reduced by 18.05% in the rate of weak and poor levels and increased by 23.61% in the rate of pretty good and good levels).

Comparing the curriculums at the Universities of Education - Hue University and Saigon University, it can be seen that some skills that students have been trained in the process of teaching specialized subjects. In these skills, most students were pretty good before the experiment such as the skill of taking appropriate actions for laboratory safety situations and the skill of using chemicals, facilities, and equipment for experimental practices. These skills were also the ones with the least variations during the experiment. There were the skills that students have not had much practice before but could be acquired more easily during short training shown as highly variances (> 40%), including the skills of taking appropriate actions for laboratory safety situations, taking appropriate measures to deal with situations of deviation in experimental results, and preparing specimens and materials for experimental practices.

We also processed the sample mean values by the Duncan test and obtained the results shown in Table 8 and Figure 8.

Table 8. The comparison of mean values of pedagogical students' teaching skills in experimental practical lessons across the experiment

The elements of teaching competences	Indicators	Pre-test	Mid-test	Post-test	Total variance
1. Preparing for practical experiments	Preparing specimens and materials for experimental practices	$2.22^{c} \pm 0.116$	$2.75^{b} \pm 0.135$	$3.47^{a} \pm 0.138$	50.05
	% variance	23.87	26.18		
	Using chemicals, facilities, and equipment for experimental practices	$3.22^{c} \pm 0.130$	$3.60^{b} \pm 0.121$	$4.08^{a} \pm 0.110$	25.13
	% variance	11.80	13.33		
	Designing and doing practical experiments in the lessons	$2.88^{c} \pm 0.120$	$3.47^{b} \pm 0.095$	$3.79^{a} \pm 0.106$	29.71
	% variance	20.49	9.22		
	Anticipating teaching situations in the laboratory and suggesting the appropriate measures	$2.69^{c} \pm 0.135$	$3.17^{b} \pm 0.158$	$3.96^{a} \pm 0.111$	42.76
	% variance	17.84	24.92		
2. Handling teaching situations in the laboratory	Taking appropriate measures to deal with situations of deviation in experimental results	$2.50^{c} \pm 0.124$	$3.14^{b} \pm 0.126$	$3.72^{a} \pm 0.124$	44.07
	% variance	25.60	18.47		
	Taking appropriate actions for laboratory safety situations.	$3.47^{b} \pm 0.114$	$3.78^{b} \pm 0.122$	$4.11^{a} \pm 0.094$	17.66
	% variance	8.93	8.73		

* The score is calculated as the average score of the skills formed in each competence (on a scale of the levels from 1 to 5, in which level 1 is the wost level, level 5 is the best level of each skill), % variance is the increased percentage of the average score at the current time in each test with the previous time point. The letters a, b, c indicate the statistically significant difference of

the sample mean at $p<0.05$ (Duncan's test). Values marked with the same letter are not significantly different at $p<0.05$.

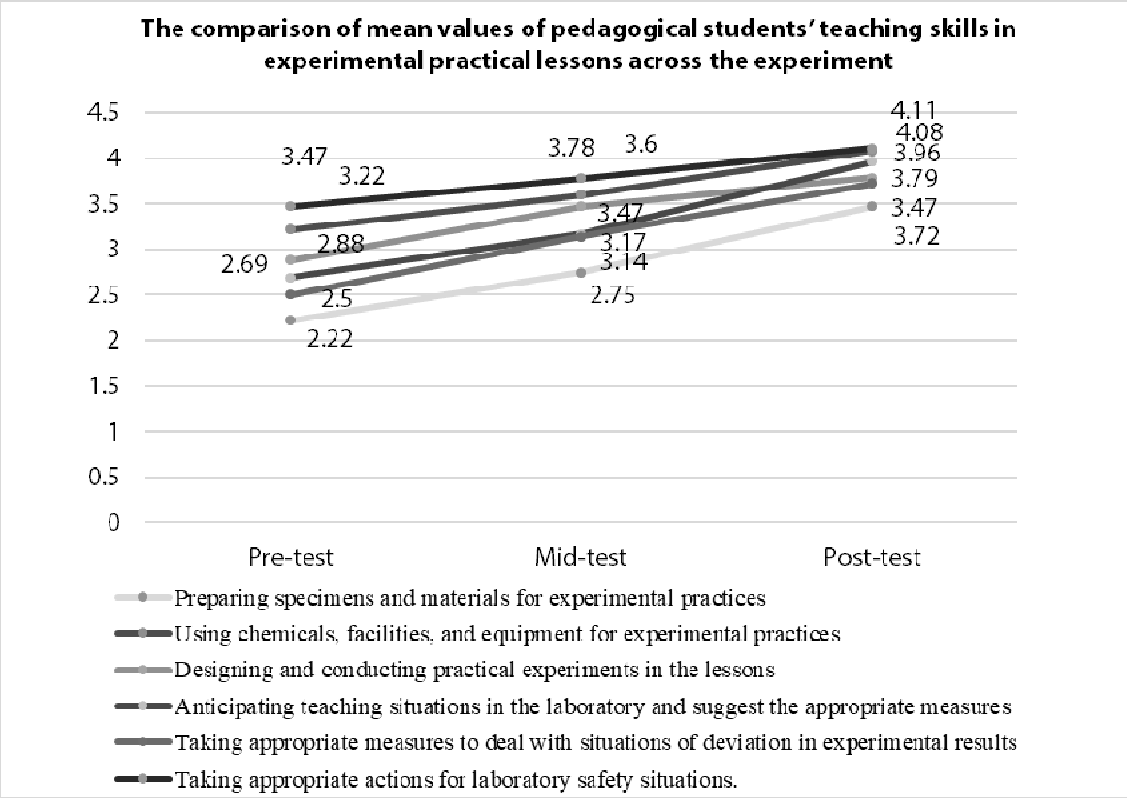


Figure 8. Graph of the comparison of mean values of pedagogical students' teaching skills in experimental practical lessons across the experiment

The above chart shows that all six indicators of two elements of component competences in the teaching competence of pedagogical students in experimental practical lessons, which are the element of competence to prepare for practical experiments, and the element of competence to handle teaching situations in the laboratory increased. That was shown through three timelines of measurement, specifically:

– Before the experiment, the best skill that students could perform was the skill of taking appropriate actions for laboratory safety situations (3.47), the worst skills were the skill of preparing specimens and materials for experimental practices (2.22) and the skill of taking appropriate measures to deal with situations of deviation in experimental results (2.50). From this result, it was supposed that pedagogical students were even quite good at taking appropriate actions for laboratory safety situations but they were not used to prepare for the experiments themselves and did not deal well with situations of deviation in experimental results.

– During and after the experimental process, all the students' skills were increased. In which, the most significant changes were the skills of preparing specimens and materials for experimental practices and practical materials (50.50%), taking appropriate measures to deal with situations of deviation in experimental results (44.07%), and anticipating teaching situations in the laboratory and suggesting the appropriate measures (42.76%). This result showed that these skills were the skills that could be rapidly improved in a short time if students were trained well.

From the results of the pedagogical experiment, it can be seen that if there are appropriate training measures, it is possible to improve the teaching competence of Biology experimental

practical lessons for pedagogical students. Some elements of this competence could be improved in a short time. But some other elements may require a long time and should be continued to be self-trained by students in the future.

CONCLUSION

Through the research, the structural model of pedagogical students' competence in teaching Biology experimental practical lessons was determined. It has three core component competences: competence to design these lessons, competence to implement the teaching activities of these lessons, and competence to assess students in these lessons. This study also showed the corresponding indicators of core competences. On this basis, we have proposed seven measures to improve the teaching competence in Biology experimental practical lessons for pedagogical students. Due to time constraints, we only chose two elements of this teaching competence for the pedagogical experiment. The experimental results showed that the suggested measures to improve this teaching competence for pedagogical have brought a remarkable effect in the two assessed competences. Therein, some elements have been significantly improved in a short time, including the skills of preparing specimens and materials for experimental practices and practical materials, taking appropriate measures to deal with situations of deviation in experimental results, and anticipating teaching situations in the laboratory and suggest the appropriate measures. This result showed that these teaching measures are necessary and significant in the teaching at the universities of education to contribute to the improvement of teaching competence for Biology pedagogical students. From here, we also suggest that universities of education should increase the application of measures to improve the pedagogical students' competence in teaching Biology experimental practical lessons to meet the requirements of educational innovation towards a competency-based approach.

REFERENCES

1. Amstrong, M. (1998). *A handbook of personel management practice*, 5th ed.. Kogan Page, London.
2. Dinh, Q.B., Nguyen, D.T (2001). *Theory of teaching Biology (general part)*. Education Publising House, Hanoi.
3. Eisenschmid, E., Löfström, E. (2014). *The Meaningfulness of the European Commission Policy Paper Improving the Quality of Teacher Education: Estonian Teachers', Teacher Educators' and Policy Makers'*. Retrieved from: https://www.researchgate.net/publication/228645193_The_Meaningfulness_of_the_European_Commission_Policy_Paper_Improving_the_Quality_of_Teacher_Education_Estonian_Teachers'_Teacher_Educators'_and_Policy, on September 06, 2019.
4. European Commisson (2013). *Supporting teacher competence development for better learning outcomes*. Europe.
5. Hager, P., & Gonczi, A. (1996). What is competence? *Medical Teacher*, *18*(1), 15-18.
6. La, T.T. (2019). Developing teaching competency for Art pedagogical students based on experiential education. *Journal of Education*, Special number (7/2019), 266-271.
7. Ly, H.H., Cao, C.C., Le, H.D. (2018). *Developing the pratical experimental competence in teaching Chemistry for pedagigical students*. Retrieved from: http://viensptn.vinhuni.edu.vn/nghien-cuu-khoa-hoc-va-hop-tac-quoc-te/seo/phat-trien-nang-luc-day-hoc-thuc-hanh-thi-nghiem-cho-sinh-vien-su-pham-hoa-hoc-85281, on September 12, 2019.
8. Ministry of Education and Training (2018). *The general education program – Master program* (Issued together with the Circular No. 32/2018/TT-BGDDT dated December 26, 2018 of the Minister of Education and Training). Hanoi.

9. Ministry of Education and Training (2018). *The general education program in Biology* (Issued together with the Circular No. 32/2018/TT-BGDDT dated December 26, 2018 of the Minister of Education and Training). Hanoi.
10. Moore, D. R., Cheng, M., & Dainty, A. R. J. (2002). Competence, competency and competencies: performance assessment in organisations. *Work Study*, *51*(6), 314-319.
11. Olsson, T., Mårtensson K., and Roxå T. (2010). Pedagogical Competence – A Development Perspective from Lund University, *A Swedish Perspective on Pedagogical Competence*, edited by A. Ryegard, K. Apelgren and T. Olsson, 121-132. Uppsala University.
12. Rahman, M.H. (2014), Professional competence, pedagogical competence and the performance of Junior High School of Science Teachers. *Journal of Education and Practice*, *5*(9), 2014.
13. Vu, X.H. (2016). About the system of teaching competence of teachers in vocational education institutions according to the competency. *Science Journal of Vocational Training Education*, *30* (3/2016), 1-6.
14. Wong, S. (2020). Competency definitions, development and assessment: A brief review. International Journal of Academic Research in Progressive Education and Development, 9(3), 95-114.
15. Woodruffe, C. (1993). What is meant by a competency?. *Leadership & Organization Development Journal*, *14*(1), 29-36.

About the authors

– **Assoc. Prof. Dr. Phan Duc Duy** is an educator and researcher in the field of biological teaching methods at the University of Education, Hue University. His research fields are case exercises in teaching, developing biology teaching skills, developing critical thinking skills for students. He has had 35 articles published in prestigious national and international scientific conferences/ journals, conducted 10 research projects, and wrote 10 books relating to this research area.

– **M.Ed. Pham Thi Phuong Anh** is an educator and researcher in the field of biological teaching at the University of Education, Hue University. Her main research fields include constructivism as a theory for teaching and learning, the measures to develop students' competencies and evaluate students' competencies. She has had 10 articles published in prestigious national conferences/ journals, conducted 2 research projects and wrote a book relating to this research area.

– **Dr. Dang Thi Da Thuy** is an educator and researcher in the field of biological teaching methods at the University of Education, Hue University. Her main research fields include curriculum development, measures to develop students' competencies in teaching biology, teaching biology based on problem-based learning, and environmental education in teaching biology. She has had 29 articles published in prestigious national conferences/ journals, conducted 6 research projects, and wrote 4 books relating to this research area.

– **Dr. Nguyen Thi Dieu Phuong** is an educator and researcher in the field of biological teaching methods at the University of Education, Hue University. Her main research fields are teaching to develop learners' competencies, organizing experiential activities in teaching biology, testing and evaluating students' competencies and integrated teaching. She has had 25 articles published in prestigious national conferences/ journals, conducted 3 and participated in 5 research projects, and wrote 4 books relating to this research area.

– **M.Ed. Le Minh Duc** is a predoctoral fellow in the Theory and Methods of Teaching in Biology in the Biology department at the University of Education, Hue University. His main research fields include handling situations in teaching biological experiments and teaching equipments.