

Designing and Testing Electronic Coursebook to Develop Student's Competence in Experimental Practical Methods in Teaching Chemistry at the Universities of Education in Vietnam

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Abstract This article introduces an electronic coursebook for experimental practical methods in teaching chemistry in attempt to develop pedagogical students' competence. Four principles, six steps in designing and two ways to use this electronic coursebook for developing pedagogical students' competence are introduced. Results of pedagogical experiments in teaching the module "Practical experiment about teaching method in chemistry" for third-year students of the courses in 2015-2016 and 2016-2017 at some universities of education in Vietnam have shown the efficiency and the feasibility of using electronic coursebook for pedagogic students in chemistry. The participants of those pedagogical experiments were asked to use the electronic coursebook before chemical experiments in the laboratory were conducted, following four steps: (i) Participants answered objective test questions on the skills to perform experiments in the laboratory, safety notes and successes of the experiment; (ii) Participants carried out simulations of experiments in the syllabus, and observed the setting up apparatuses of laboratory and the sequence of experiments; (iii) Participants carried out experiments in small groups in the laboratory under the supervision of instructors; and (iv) Teachers asked participants to do the available tests in the electronic coursebook to assess their learning outcomes.

Keywords: *electronic coursebook, experimental practical methods, teaching method, chemistry, pedagogic students*

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1. Introduction

Chemistry is a subject that involves experimentation which could be more exciting whenever conducted through laboratory experiment where the results are more memorable by their senses [1]. When simulated chemistry laboratories are implemented effectively, students can have additional opportunities to engage in meaningful pedagogical experiences. Through our evaluation of the inorganic Virtual ChemLab, Brian et al., [2] have found that if effectively used it (i) provides "practical experience" by connecting the "theory" taught in the classroom with the "real world" of the laboratory, (ii) provides a realistic learning environment for different learning styles, and (iii) teaches the cognitive processes (or analytical skills) that form the foundation of chemistry and other laboratory sciences.

Information and communication technology has shown its usefulness and importance in almost every aspect and

careers nowadays. With education, the information technology and the media have created "the revolution" in teaching – learning and they are "the key" to increase the quality of education [3]. In educational science, teacher can deploy different methods to use information and communication technology efficiently, include: using information and communication technology reasonably to increase the value of study action, linking information and communication technology to teaching and learning, encourage students to share their ideas and find information... [4]. Previous studies have shown the benefits of using information and communication technology in chemical education. Here are some of those: Animations and dynamic visualisations [5,6]; CD-ROMs and simulations [7]; Computerized molecular modelling [8,9]; Virtual worlds [10]; Interactive whiteboard technology [11]; Using an interactive software program, Virtual Chemistry Laboratory (VCL) to assess the software's influence on student understanding of some basic organic chemistry laboratory techniques [12]; SimuLab computer-based learning environment. The SimuLab is a cognitive tool

designed to help students to acquire experimental and analytical skills on the basis of a classical qualitative and quantitative analysis scheme and to develop their ability to interpret experimental results [13].

Results of an attitudinal survey showed that students expressed similarly favorable views of the hands-on and virtual experiments, and they found that report writing was equally challenging for both types of experiments. According to Kurt, Matthew, & Deborah [14], the virtual experiment required significantly less time to complete.

One of ICT's applications in teaching today is designing for electronic coursebook. Various authors have published ebooks [15] or created the websites to support for students in studying and research [16].

"The practical experiment about teaching method in chemistry" is an important subject, which is indispensable in training syllabus for pedagogic students in chemistry. Students can not only obtain the teaching of chemical experiment theory but also train abilities as analyzing purposes and significance of every chemical experiment in high school programs. Moreover, students can develop teaching methods and organization abilities; they can guide the learner in performing experiments. Therefore, using information technology with multimedia devices to design ebooks for this subject includes documents, experiment simulation, interaction test questions, ... will be the tools to support for student to practise the experimental practical skills in teaching chemistry.

2. Designing Electronic Coursebook for Experimental Practical Methods in Teaching Chemistry

2.1. Softwares Design Electronic Coursebook

There are many design electronic coursebook softwares as Lectora, Moodle, eXe, Macromedia Dreamweaver ... In our research, Macromedia Dreamweaver software was chosen because of their available functions such as insert flash, video, change theme following ideas, create hyperlink... [17].

To enhance interaction, we also used Macromedia Flash MX 2004 software to design the simulation [18], iSpring QuizMaker software to design the multiple-choice test [19].

2.2. Principles in Designing Electronic Coursebook

To design an electronic coursebook with high quality, the designing process must adhere to pedagogical principles. We built the principles for designing electronic coursebook as follow:

a) Guarantee the science

This principle requires that electronic coursebook's contents are precise and modern. Experiment systems in electronic coursebooks are built with linking content of the subject "The Practical Experiment about Teaching Method in Chemistry".

Moreover, electronic coursebook must be designed simply, consistently and easily to understand conveniently. The document, figure, simulation, video... in electronic coursebooks must be coherent with content and students' level, attractive to use.

b) Guarantee the pedagogical

Designed electronic coursebook has to be logical and contain a clear lay out. It accommodates with student's level, to help improve the creation in student's awareness.

Virtual experiments must match the actual size with clear phenomenon and easy observation. Multiple-choice questions must be available in the experimental content to assess students' learning outcomes.

c) Guarantee the usability

This is an important principle in designing electronic coursebooks. It guarantees to use at everywhere, anytime. Everyone can use widely, easily, available in normal computer in the long time with update ability.

Learners can interact with coursebooks, teachers and other students through e-learning system.

d) Guarantee the aesthetics

Designed electronic coursebooks that are harmonious, logically sized, clearly colored, and contain exact simulations about experiments and structures, in order to help students to understand and search the reference information easily.

2.2. Steps in Designing Electronic Coursebooks

It includes 6 steps as following:

Step 1: Analyzing situations to propose appropriate goals

Step 2: Determining the key and basic knowledge

Step 3: Building the teaching scenario

Step 4: Building the document system for electronic coursebook

Step 5: Choosing software that can perform easily the simulations and digitalizing electronic scenario

Step 6: Trial running, editing and completing the electronic coursebook.

3. The Content of Electronic Coursebooks for Experimental Practical Methods in Teaching Chemistry

The Electronic coursebook for the subject "Practical experiment about teaching method in chemistry" was designed with the below structure (see Figure 1).

Cover: Introduce electronic coursebook's name, author's preface.

Guide: Learner operates the functions and procedures to get efficiency.

Content: Electronic coursebook includes 10 subjects about experimental practical methods in teaching chemistry according to chemistry textbook of grades 10, 11, 12 in Vietnam, splitting the experimental subject into many small knowledge modules. Scenarios' main content of electronic coursebook includes (see Figure 2).

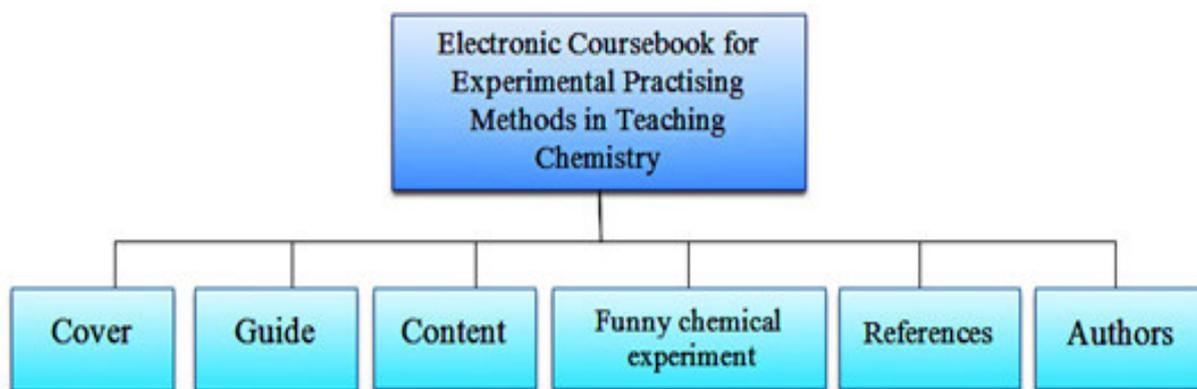


Figure 1. Content of Electronic Coursebook for Experimental Practical Methods in Teaching Chemistry

Figure 2. Topic of an experimental lesson in the electronic coursebook

3.1. Name of the Topic of Experiment

Target of experimental subject: Determining the knowledge targets, skills, attitude and competence to propose appropriate content and test.

List of experiments: Determining list of experiments and rearranging in order (No. 1, No. 2, ...) The experimental module includes the following knowledge:

Name of experiment.

Chemicals and tools: List all of chemicals and tools.

Experimental technique: How to conduct the experiment, how to assemble tools.

Note: List the notes for successful safety experiments.

Illustrated simulation: Simulation illustrates how to install the instruments (apparatuses), conducting experiments and phenomena occur.

Question: Based on the content of the experiment, multiple choice questions were designed in accordance

with the content of the experiment and the level of awareness of the students. This system of questions is written by test software in the form of interaction with learners (<http://www.ispringsolutions.com/ispring-quizmaker>).

Test: Determining the knowledge system about chemical experimental skills obtained when students study experimental lessons. Forming multiple choice questions on computer software to consolidate and inculcate knowledge about chemical experimental skills for students.

Link to website: Introducing related websites for learners.

Funny chemical experiments: Introducing some funny experiments for learners. They can use for chemical extracurricular activities.

References: Supporting documents can be used.

Authors: Introducing electronic coursebook's authors.

Knowledge modules in the Electronic Coursebook (see Figure 2 and Figure 3)

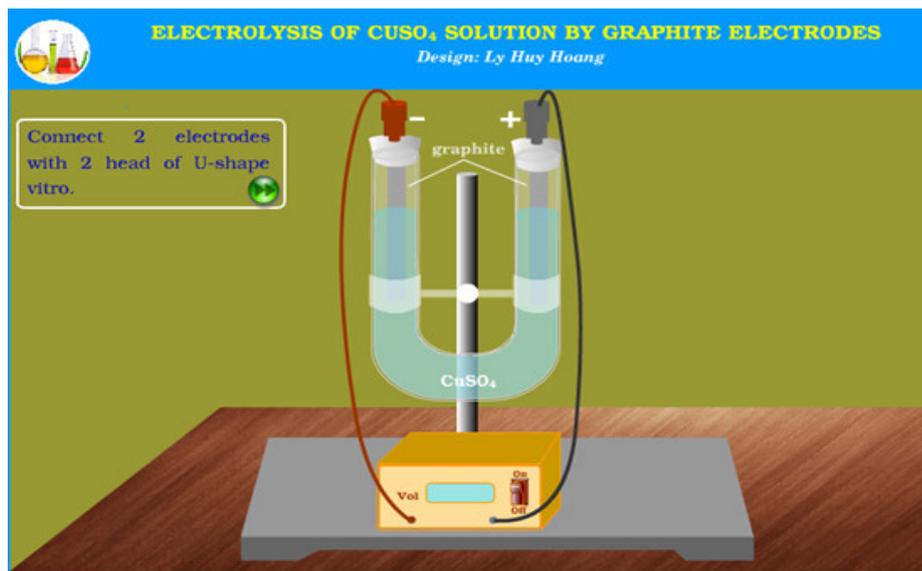


Figure 3. Simulated experiment about copper sulfate solution

4. Using Electronic Coursebook to Develop Pedagogical Student's Competence

Electronic coursebook is used in two forms: before or during doing experiments.

Form 1: Electronic coursebook is used before doing experiments.

In this form, electronic coursebook supports students in self-learning at home.

Basic knowledge about using laboratory apparatuses, common chemicals, some basic activities in the lab of chemistry teaching method.

Students can understand some experimental operations and skills in the chemistry programs of grades 10, 11, 12 in Vietnam.

Students can practice the experimental performance

skills by experimental simulation. They can orient the ways to use experiments in chemistry program of grades 10, 11, 12 in Vietnam.

Using electronic coursebook before doing experiments can decrease the time to study the experimental procedure and can increase the time to practise experimental skills, and organize the experiment activities in high school. These activities can help to form experimental practical competence and organize teaching the experiments in chemistry.

Form 2: Electronic coursebook is used during doing experiments.

The using sequence of electronic coursebook in lessons as following:

Use multiple choice test (see Figure 4) to check the student's preparation at home. The questions were designed in multiple-choice type with contents connected to the notes in safety, and the experimental skills to succeed.

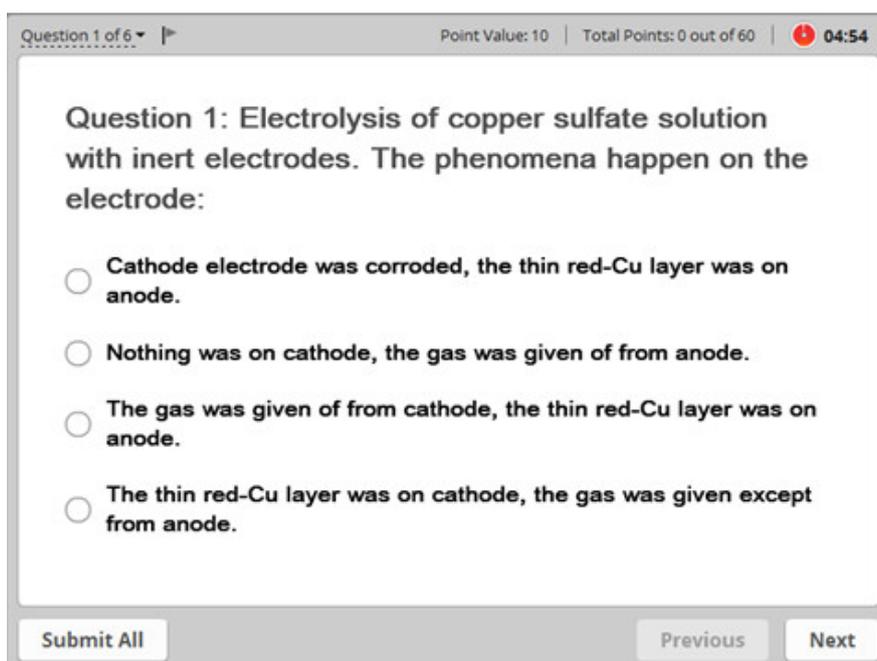


Figure 4. System of questions

Teachers use electronic coursebook to guide and emphasize the notes, using tools, chemicals, difficulties and experiences to have experimental success.

Students observe experimental simulations to get familiar with how to assemble the tools, operations in experiment.

Students carry out experiments in small groups.

Using electronic coursebook to check the experimental results through experiment simulations. Test the students' obtained knowledge by multiple-choice test on computer designed by electronic coursebook.

Example: Teaching in halogen topic (in this example, we illustrate an experiment about preparing and collecting chlorine gas in lab).

Action 1: Lecturer opens electronic coursebook and introduces the list of experiments.

Action 2: Test the homework contents of students (see Figure 5).

Lecturer invites about 2 – 3 students to do the test with contents in electronic coursebook, to examine the skills of using experiment, the notes about skills for safe and success.

Lecturer comments the homework preparation of students.

Action 3: Lecturer guides to do the experiment and practise the experimental skills in electronic coursebook (see Figure 6).

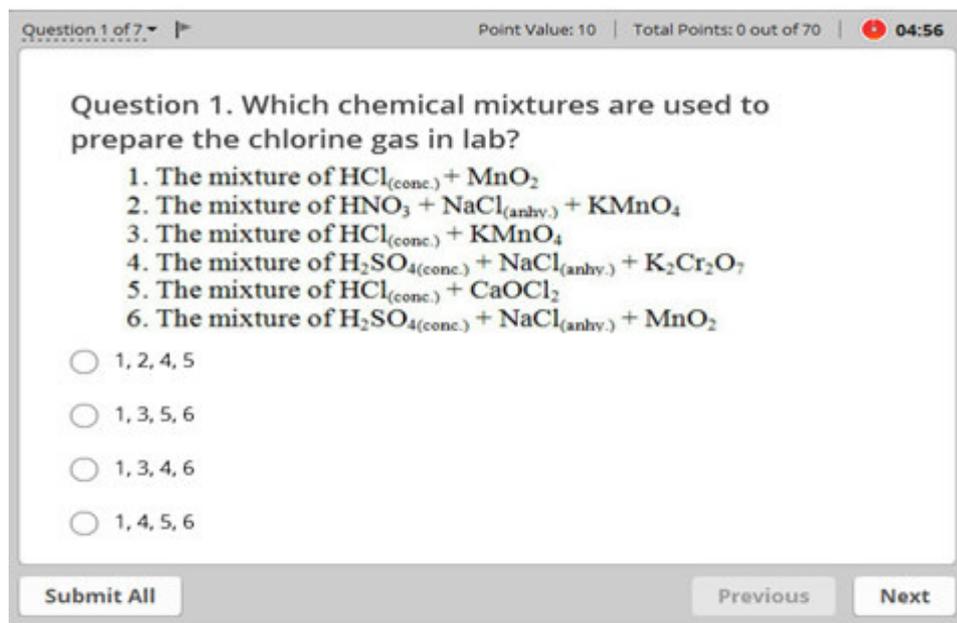


Figure 5. Theme of test “The experiment about preparing and collecting chlorine gas”

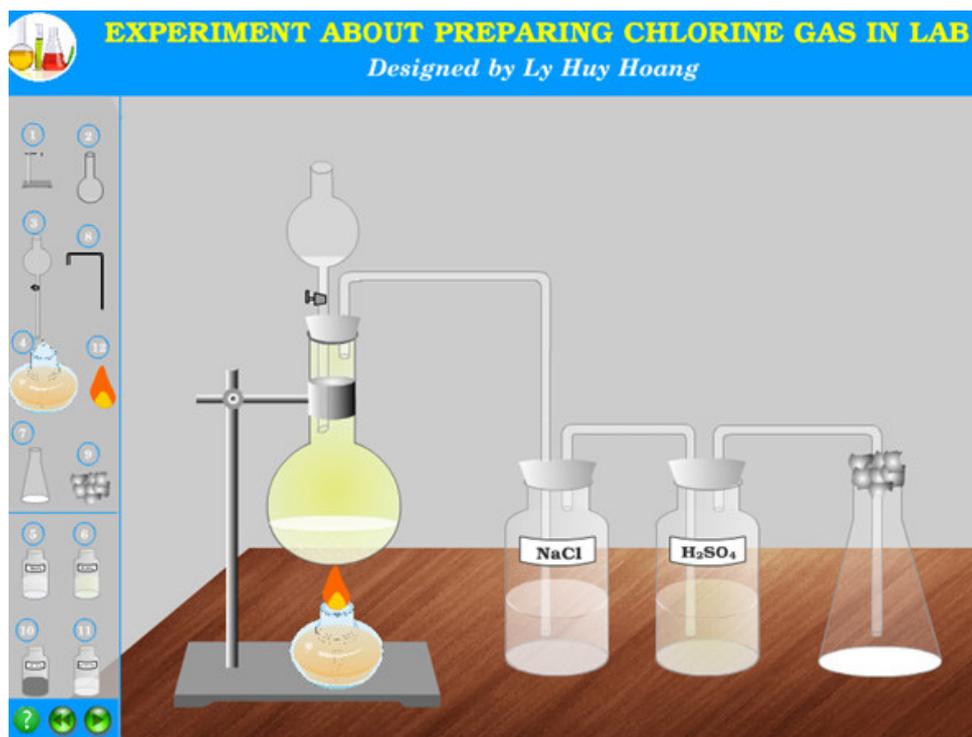


Figure 6. Simulated experiment about preparing and collecting chlorine gas in lab

Lecturer shows the experiment simulation to note the assembly of tools, experimental skill base on observed simulations.

Lecturer requests their students to discuss the notes when they do experiment successfully.

Lecturer notes the important contents in every experiment.

Chlorine is poisonous gas, we must conduct experiment in the laboratory fume hood, only prepare a little chlorine gas to use; have the knowledge about the poisoning prevention and can provide first aid to the poisoned person.

Action 4: Discuss about the using experiment in organizing to teach and learn chemistry in high school.

In experiments about halogen group, which experiment will be done in research method? which experiment to discover and to solve the problems? which experiment to check? To choose the experiment method, we need to explain the chosen reason and show the location of experiment in chemistry lesson.

Apply empirical knowledge to explain the situations in life.

Action 5: Students do experiment in small group; lecturer observes, guides, notes to safe successful experiment; lecturer chooses a random group to record video of the experiment operations.

Action 6: Test the students in knowledge related to experimental skills, lecturer uses the available test in electronic coursebook to test about 2 – 3 students (see Figure 7).

5. Data Collection and Analysis

To verify the valuation of electronic coursebook, we have collected the learners' comments by survey. We obtained 102 survey questionnaires from third-year students of the courses in 2015 – 2016 and 2016 – 2017 at Dong Thap University, Vinh University, Hanoi University of Education in Vietnam. The obtained results presented in Table 1.

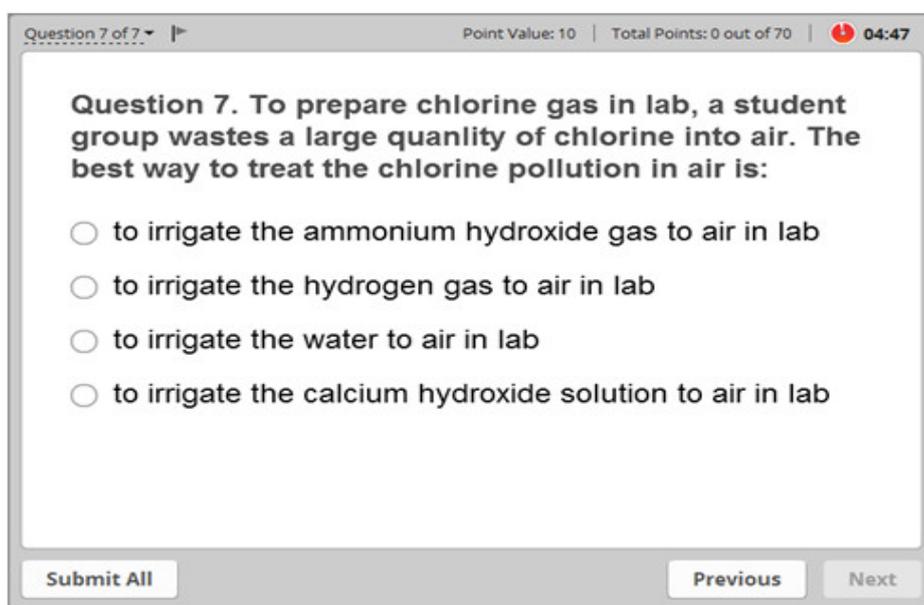


Figure 7. System of questions

Table 1. Awareness of students about the effects in using electronic coursebook.

Criteria	Level			
	1	2	3	4
1. Evaluation of content				
The accuracy of knowledge	5.88	24.51	55.88	13.73
The science and pedagogy	2.94	11.76	62.75	22.55
Practical exercises in the coursebook have tested a lot of knowledge related to the chemical experiments	3.92	18.63	69.61	7.84
Simulate experiments in the electronic coursebook is appropriate for experimental contents	4.90	11.76	62.75	20.59
2. Evaluation of presentation form				
Consistency in display	2.94	8.82	75.49	12.75
Easy in access the necessary part	4.90	7.84	60.78	26.47
Beautiful interface, harmonious color, aesthetic simulation	7.84	14.71	53.92	23.53
3. Evaluation in feasibility				
Compatible content with the practice of experimental skills	5.88	10.78	71.57	11.76
Compatible content with practical skills of the using experiment in teaching chemistry	7.84	15.69	50.00	26.47
Support for all of students in learning chemistry	1.96	8.82	77.45	11.76
Being convenient in using the computer in teaching	0.98	6.86	85.29	6.86
4. Evaluation in usability				
Support for students in practise the experimental skills to decrease the preparation time for experiments	7.84	14.71	61.76	15.69
Develop the student's activation, creation in practising the chemical experimental skills.	3.92	11.76	66.67	17.65
Support for designing the plan of lesson and using experiments in teaching chemistry.	6.86	13.73	70.59	8.82
Test knowledge related to practising the chemical experimental skills.	11.76	8.83	61.76	17.65
Increase the excitement of students' learning	2.94	7.84	76.47	12.75

Note: Level 1: weak; Level 2: medium; Level 3: good; Level 4: very good; Unit: %.

To assess the impact of the electronic coursebook on the development of student experimental competence, we used the table in observation by self-student. We have surveyed to students: testing before impacting and after impacting to only group. Designing for this study is as follows:

- O₁ ----- X ----- O₂
 O₁ ----- Before Impacting (BI)
 O₂ ----- After Impacting (AI)
 X ----- Using the electronic coursebook

Result will be evaluated by comparing the difference of average values of results before and after impacting. If $|O_2 - O_1| > 0$, X (impacting) has effect.

Before impacting: Organizing for students to make survey questionnaires about the experimental practical competence in chemistry before getting access to the electronic coursebook.

After impacting: The second survey, students evaluate developing their competences base on the criteria with 4 levels as the Table 2 and Table 3.

Table 2. Survey results before and after impacting to experiment practice competences about chemistry (N = 102).

Express Competences / Criteria	Level							
	1		2		3		4	
	BI	AI	BI	AI	BI	AI	BI	AI
1. Comply the regulations and laboratory safety rules	8	2	49	19	43	65	2	16
2. Use and preserve the tools and chemicals in lab according to regulations	7	1	52	6	42	64	1	31
3. Identify and choose the necessary apparatuses, chemicals for experiments	12	1	49	11	36	50	5	40
4. Assemble all of parts in every experiments, understand the its function, analysis the right/wrong in assembling the apparatuses	16	2	52	9	32	57	2	34
5. Use the apparatuses and chemicals competently	10	3	51	10	39	56	2	33
6. Perform the experiments safely, right as procedure and success.	8	4	47	10	43	66	4	22
7. Observe and identify the experimental phenomena	13	1	46	14	38	57	5	30
8. Describe the phenomena exactly, give the conclusion	14	3	49	17	38	56	1	26
9. Apply the theory to explain the experimental phenomena scientifically	20	3	47	9	33	55	2	35
10. Analysis and process the experimental results	19	4	48	8	32	56	3	34

Note: Level 1: 1 mark (bad); Level 2: 2 marks (average); Level 3: 3 marks (good); Level 4: 4 marks (very good) ; BI: Before Impacting; AI: After Impacting.

Table 3. Level of developing the experimental practice competence for pedagogical students in chemistry.

Component competences	Level of development			
	Level 1	Level 2	Level 3	Level 4
Use the experiment safely and exactly	No regulations, laboratory safety rules have been implemented	Implement some regulations and lab safe rules	Implement regulations and laboratory safety rules completely	Implement regulations and laboratory safety rules very well
	It is not known to use and preserve tools and chemicals in lab.	It is known to use and preserve simple apparatuses and chemicals in lab.	Understand principles to use and preserve the apparatuses and chemicals in lab.	Use effectively and understanding of preserving apparatuses and chemicals in the lab.
Perform the experiment	Can not choose the necessary apparatuses and chemicals for the experiments	Some apparatuses and chemicals is wrong chosen for the experiments	Choose apparatuses and chemicals appropriately for the experiments	Choose apparatuses and chemicals for the experiments creatively
	Can not assemble or incorrectly assemble the kits for the experiment	Assemble correct tools for experiment but do not understand the application of some parts, don't know the correctness of assemble process	Assemble correct tools for experiment, understand the application of some parts, know the correctness of assembling process	Assemble correct tools for experiment, and understand the application of every parts, know the correctness of assembling process
	Can not use the tools, chemicals for experiments	Know the use of tools, chemicals for experiments	Use appropriately for the tools and chemicals for the experiments	Use very well the tools and chemicals for the experiments.
	It is almost impossible to do experiments	Experimental process is safety, experimental process is inappropriate, but successful	Experiment is safety, right process, success.	Experiment is safety, right and clear process, successful experiments. Easily to observe the results.
Observe, describe the experimental phenomenon and the conclusions	Do not detect the experimental phenomena	Know the observed method, but confirm the phenomena is not clear	Confirm clearly the experimental phenomena but not yet fully	There is the observation method, clearly and fully awareness of the experimental phenomena.
	Can not describe the experimental phenomena, can not draw the conclusions	Describe the experimental phenomena fully, but can not draw the conclusions	Describe the experimental phenomena fully, and can draw the conclusions	Describe accurately the experimental phenomena, drawn the conclusions fully
Process information related to experiment	Do not know to apply the theory to explain the experimental phenomena	Apply the theory to explain the experimental phenomena, but not fully	Apply the theory to explain the experimental phenomena, but representation is not fluent	Apply the theory to explain the experimental phenomena in a accurate scientific way
	Do not have ability to analysis, to process the experimental results of some quantitative experiments	Students can analysis and process the experimental results of some quantitative experiment with the help of friends and lecturers	Know to analysis and process the experimental results of quantitative experiments	Analysis and process the results of some quantitative experiments proficiently

Note: Level 1: 1 mark (bad); Level 2: 2 marks (average); Level 3: 3 marks (good); Level 4: 4 marks (very good).

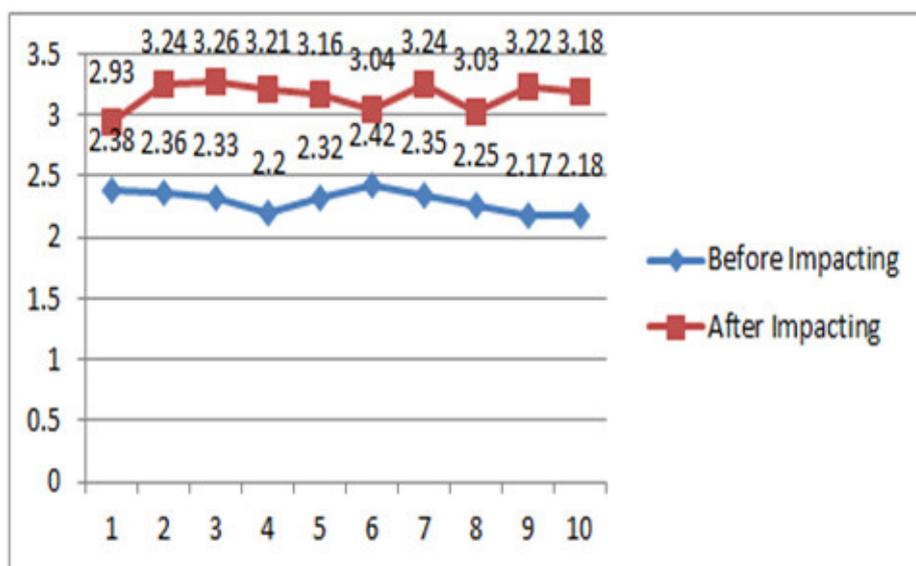


Figure 8. The chart of average value before and after impacting

Table 4. Values of the measurement before and after impacting of 102 participants (pedagogical students in chemistry) in Vietnam

Criteria	Average value		Standard deviation		Reliability factor		Variance	
	BI	AI	BI	AI	BI	AI	BI	AI
1	2.38	2.93	0.661	0.649	0.678	0.689	0.437	0.421
2	2.36	3.24	0.626	0.600	0.711	0.713	0.392	0.360
3	2.33	3.26	0.749	0.688	0.698	0.701	0.561	0.474
4	2.20	3.21	0.718	0.680	0.681	0.715	0.516	0.462
5	2.32	3.16	0.677	0.714	0.681	0.722	0.459	0.510
6	2.42	3.04	0.696	0.688	0.700	0.696	0.484	0.474
7	2.35	3.24	0.753	0.720	0.665	0.715	0.567	0.518
8	2.25	3.03	0.699	0.737	0.638	0.719	0.489	0.544
9	2.17	3.22	0.759	0.712	0.649	0.601	0.576	0.507
10	2.18	3.18	0.750	0.737	0.601	0.600	0.563	0.543

Table 5. Summary of the characteristic parameters before and after impacting.

	N	Mean	Standard deviation	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				t-test for Equality of Means				
				Lower	Upper			
Criteria 1	102	-0.549	0.709	-0.730	-0.368	-5.988	101	0.0002
Criteria 2	102	-0.873	0.752	-1.042	-0.703	-10.163	101	0.0001
Criteria 3	102	-0.931	0.856	-1.130	-0.733	-9.247	101	0.0003
Criteria 4	102	-1.010	0.862	-1.203	-0.817	-10.314	101	0.0001
Criteria 5	102	-0.833	0.810	-1.025	-0.641	-8.552	101	0.0002
Criteria 6	102	-0.618	0.756	-0.809	-0.427	-6.375	101	0.0005
Criteria 7	102	-0.882	0.858	-1.086	-0.679	-8.553	101	0.0001
Criteria 8	102	-0.775	0.815	-0.973	-0.576	-7.698	101	0.0003
Criteria 9	102	-1.049	0.903	-1.252	-0.846	-10.179	101	0.0002
Criteria 10	102	-1.000	0.895	-1.205	-0.795	-9.606	101	0.0001

Note: Significant at the $p < 0.05$ level.

We used SPSS software to analysis experimental data, the obtained results confirm the impacting effects [20]. The parameters are are represented in Table 4, Figure 8, and Table 5.

6. Results and Discussion

Results of survey the students' awareness about efficiency in using electronic coursebook to develop the experimental competence in chemistry are illustrated in

Table 1. The results show that the assessments about content, form, feasibility and efficiency have level 3 and level 4 with high rate. It was also found that the using electronic coursebook in organizing learning the module "The practical experiment about teaching method in chemistry" to help studens practise the experimental skills, decrease the preparation time before doing the experiment, good support for designing teaching plan and using experiment in teaching and learning chemistry. Students can self-test the knowledge related to experimental practical skills in chemistry.

The results in Table 4 and Table 5 show the homogeneity of average value Sig.(2-tailed) < 0.05 (*Significant*). The difference of the results before and after impacting is not random, it only happens when there is an impact (used the appropriate method). The difference average value and standard deviation is high, it demonstrates the effect of using the methods to form and develop experimental skills about chemistry for students is very big. The average mark after impacting is higher than the average mark before impacting with random occurred probability < 5%. It confirms the procedure and developing method about experimental competence in chemistry for students is efficiency.

The pedagogic experimental results show that the using electronic coursebook to organize the teaching activities of experiment in teaching chemistry is very necessary to help students practice the experimental skills by experimental simulations and exercises in the electronic coursebook. By the simulations, students assemble the experimental apparatuses, observe the experimental phenomenon before coming into lab. Students can interact with experimental exercises' system in the electronic coursebook with test software, it can help students to check the knowledge and skills in lab.

7. Conclusion

Electronic Coursebook for Experimental Practical Methods in Teaching Chemistry that integrated figures, simulated experiments, software to test knowledge, ... is the document source to develop competences as the experimental practice skills in teaching chemistry, and self-study competence for students.

In terms of pedagogy, the electronic coursebook helps students prepare their chemistry lab assignments with notes about their experimental skills to ensure a successful experiment. Particularly useful for toxic experiments, expensive chemicals, too fast or too slow reactions, complex equipment, etc., are not suitable for conducting experiments in lesson.

The electronic coursebook can be used in two ways: using before experiment and using during experiment. Students can interact with simulation experiments, experimental exercises in the test software in the electronic coursebook. The experimental results of student's awareness in contents and form are good, students are interested in learning with the electronic coursebook. Experimental results with 102 pedagogical students in chemistry in Vietnam have showed that, the average mark after impacting is higher the mark before impacting with random probability < 5 %. This shows the procedure and methods to develop the experimental practical competences for students in teaching chemistry are efficient. The electronic coursebook was built including 10 lessons, which integrate 100 experiments in chemistry program at grades 10, 11, 12 in Vietnam. This document is useful for lecturers and pedagogical students in chemistry.

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Competing Financial Interests

The authors declare no competing financial interests.

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