HNUE JOURNAL OF SCIENCE
Educational Sciences 2025, Volume 70, Issue 5, pp. 168-178
This paper is available online at http://hnuejs.edu.vn/es
DOI: 10.18173/2354-1075.2025-0101

# DEVELOPING SELF-LEARNING COMPETENCE FOR CHEMISTRY PEDAGOGY STUDENTS THROUGH THE USE OF DIGITAL LEARNING MATERIALS IN THE COURSE ON DESIGNING CHEMISTRY TEACHING PLANS

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Received June 6, 2025. Revised June 28, 2025. Accepted July 11, 2025.

**Abstract.** In the period of the booming Industrial Revolution 4.0, with the rapid development of information technology (IT) and scientific techniques, teaching methods require changes to meet the learning needs of students as well as the increasing demands of society. Therefore, fostering and enhancing self-learning competency (SLC) for students is an extremely important issue. This article focuses on building and using digital learning resources to enhance SLC for students. The research process and the results of pedagogical experiments at the Chemistry Department of Hanoi University of Education are described to demonstrate the effectiveness and feasibility of using digital learning materials in developing self-learning competency for students participating in the course on Developing Teaching Plans for Chemistry. The experimental data, after statistical analysis, showed that the use of digital learning materials (DLMs) to develop self-learning competency for pedagogical students can be scaled up.

***Keywords:*** digital learning materials, self-learning competency, teaching chemistry.

## 1. Introduction

Today's world is undergoing a rapid technological revolution, and the field of education is no exception. In the trend of digital transformation, DLMs have become a common and essential concept in the education and training of students. In Vietnam, several leading authors and researchers have contributed to the field of digital learning materials and education. Professor Nguyen Minh Hong has researched the development and application of DLMs in teaching and learning. Associate Professor Tran Van Nha has studied the use of digital learning materials to enhance teaching and learning effectiveness at various educational levels. Associate Professor Nguyen Tung Linh has researched training and the development of digital competencies [1]. Similar studies on e-learning and flipped classrooms have shown that integrating digital learning tools enhances student engagement and self-directed learning. Our study extends this body of work by specifically focusing on the use of DLMs in the context of chemistry pedagogy, offering a novel perspective within the Vietnamese educational landscape. Their research has made significant contributions to the development and application of digital learning materials in education. However, there is still a limited number of research projects focusing on developing digital learning materials to foster self-learning competency for university students.

In this article, our research team investigates and evaluates the current status of DLMs development and the promotion of SLC in the course "Planning Chemistry Lessons". We propose a tool to assess the self-learning competency of Chemistry Education students when using digital learning materials in their studies. Furthermore, our team designs a learning plan (LP) that incorporates digital learning materials to develop the SLC of Chemistry Education students. To effectively organize teaching using digital learning materials, teachers not only need to shift their roles but also must invest time and effort in preparing diverse teaching resources, including lectures, exercises, assessments in various formats, and collecting images, experiments, and reference materials to inspire and motivate students in self-directed learning

With the continuous advancement of information technology, teaching materials are no longer limited to paper-based formats but also include videos, audio files, and other multimedia, collectively referred to as digital learning materials. Developing self-learning competency is becoming increasingly important in education, as it is a key factor in the personalization of learning. Many scholars and governments believe that enhancing self-learning capabilities will promote higher and lifelong learning [2]. One of the core issues in promoting self-learning is defining standards and criteria for evaluating self-learning competency. These criteria help learners to self-assess, be autonomous, motivated, responsible, and goal-oriented, manage time, self-regulate, and develop metacognition, self-awareness, and self-directed learning. In addition, an optimized process for developing students' self-learning competencies is needed to ensure they can effectively cultivate the skills necessary for lifelong learning.

# 2. Content

## 2.1. Digital learning materials

### 2.1.1. Concept

According to Clause 2, Article 2 of Circular No. 21/2017/MOET (effective from October 23, 2017) issued by the Ministry of Education and Training, which regulates the application of information technology in online training and professional development activities for teachers, staff, and educational administrators, digital learning materials (also referred to as electronic learning materials) are defined as follows: "Digital learning materials (or electronic learning materials) are a collection of electronic resources used for teaching and learning, including electronic textbooks, electronic curricula, electronic reference materials, electronic assessment and test materials, presentations, data tables, audio files, images, videos, electronic lectures, educational software, simulated experiments, and other digitized learning resources" [3].

### 2.1.2. Components of digital learning materials

Digital learning materials include many diverse and multifunctional components to support effective learning and teaching. Digital learning materials are divided into the following main types:

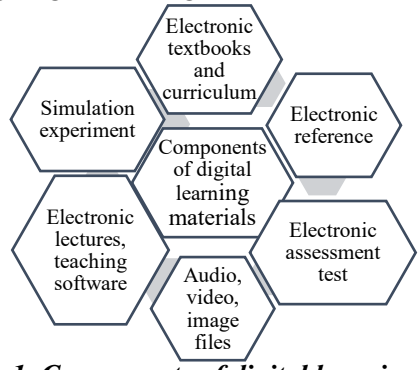


***Figure 1. Components of digital learning materials***

## 2.2. Self-learning competency

### 2.2.1. Concept of self-learning competency

Professor Nguyen Canh Toan proposed the following concept of self-learning competency: "SLC is understood as a highly complex skill attribute. It encompasses skills and techniques that must be closely tied to corresponding motivations and habits, enabling learners to meet the demands posed by their tasks" [4], [5]. SLC involves not only learning methods, learning skills, and learning content but also the integration of these elements: "SLC is the integrated combination of learning approaches and skills that influence content across a wide range of situations and problems" [4].

### 2.2.2. Structure and expression of self-learning competency

The self-learning competency standards for students in teacher training universities are a system of fundamental requirements used to assess this competency. A standard refers to the core components of self-learning competency, while a criterion refers to the specific requirements and conditions that must be met for each component of self-learning competency. The standards for assessing self-learning competency are developed based on the internal elements of this competency—specifically, the skills that individual learners need to possess. In general, current research indicates that numerous skills are essential for effective self-learning. These skills are typically categorized into three groups: cognitive, metacognitive, and affective skills. Many researchers have emphasized that all of these skills are crucial for learning [6], [7]. The standards and criteria for assessing self-learning competency [8]-[10] are described in Table 1.

***Table 1. Criteria and levels of assessment of self-learning competency development***

| **Criteria** | **Rating scale** | | |
|---|---|---|---|
| | ***Rating scale 1 (1 point)*** | ***Rating scale 2 (2 point)*** | ***Rating scale 3 (3 point)*** |
| *1. Determine goals and self-learning content* | Identify goals and content for self-learning through learning tasks, but not accurately. | Identifying the objectives, content, and level of achievement of each content in digital learning materials is not complete. | Identify goals and self-learning content through accurate and complete learning tasks. |
| *2. Determine self-learning methods and means* | It is not yet clear how to self-learn through the digital learning materials provided. | Determine if the self-learning method is appropriate for the digital learning materials provided with the self-learning content. | Identify appropriate self-learning methods using the provided digital learning materials with self-learning content. |
| *3. Determine self-learning time and expected results* | Determining the self-learning time is not reasonable; the results cannot be expected. | Determine the appropriate time for each self-learning activity and predict the results achieved. | Determine the time for each self-learning activity clearly and reasonably, and expect the results to be achieved. |

| | | | |
|---|---|---|---|
| *4. Collect/Search for self-learning information sources* | Collect/Search for self-learning resources that are inaccurate and inappropriate for self-learning content. | Collect/Search for accurate information that is suitable for self-learning content, but is incomplete. | Collect/Search for appropriate, accurate, and complete sources of self-learning information. |
| *5. Analyze and process the searched information* | Listen, understand the content of digital learning materials, understand information, but have not analyzed or processed it into conclusions. | Listen, understand the content of digital learning materials, understand information, know how to analyze and process, but do not know how to conclude. | Listen, understand the content of digital learning materials, understand information, and know how to analyze, process, and then draw conclusions. |
| *6. Apply knowledge and skills to solve learning situations/tasks.* | Apply knowledge and skills to solve learning situations/tasks, but not accurately. | Apply knowledge and skills to solve learning situations/tasks accurately but incompletely. | Apply knowledge and skills to solve learning situations/tasks accurately and completely. |
| *7. Evaluate self-learning results according to the assessment scale and standards of knowledge and skills required to achieve* | Inaccurately assess self-learning results according to the self-learning competency assessment scale and knowledge and skills standards. | Accurately but incompletely assess self-learning results according to the self-learning competency assessment scale and knowledge and skills standards. | Accurately and fully evaluate self-learning results according to the self-learning competency assessment scale and knowledge and skill standards. |
| *8. Adjust and draw lessons for the next self-learning task* | Have no suitable self-learning adjustment method. | Have suitable self-learning adjustment plans, but no lessons have been learned. | Have reasonable plans to adjust self-learning and draw lessons from experience. |

## 2.3. The process of building digital learning materials to develop students' self-learning competency

In this study, the process of developing DLMs aimed at enhancing students' self-learning competency [11], [12] is carried out in seven steps, briefly outlined as follows:

*Step 1: Define the lesson objectives:* The first step in developing digital learning materials is to clearly define the learning objectives - what competencies and qualities students are expected to achieve after completing the lesson. The objectives must align closely with the required outcomes specified in the general upper secondary chemistry education curriculum.

*Step 2: Identify key content and core knowledge:* Teachers need to align the content with the required outcomes. In addition, they may extend and deepen the content by consulting specialized reference materials.

*Step 3: Develop the teaching scenario:* The teacher creates a lesson plan and elaborates it into a detailed teaching scenario.

*Step 4: Select appropriate materials for each activity:* Based on the characteristics and content of each learning activity, the teacher prepares or collects and selects suitable materials, including videos, images, animations, etc.

*Step 5: Digitize the teaching scenario:* The teacher chooses appropriate software tools that match their own conditions and the teaching objectives, then digitizes the lesson content into digital learning materials.

*Step 6: Pilot test and consult experts:* The digital materials are piloted, and feedback is gathered from experts and colleagues.

*Step 7: Revise and finalize:* The materials are revised based on the feedback received and finalized for implementation.

## 2.4. Research methods

### 2.4.1. Research objects and information collection methods

The subjects of the study in this article are students majoring in Chemistry Education at the Faculty of Chemistry, Hanoi National University of Education, who participated in the course "Designing Chemistry Teaching Plans" during the 2023–2024 academic year. Specifically, two experimental classes were selected: class K71C with 18 students and class K72 with 36 students. These classes were chosen to ensure that the academic levels of the students were equivalent.

The data collection process was carried out in three main phases:

*Pre-experiment phase*: Students were asked to study the lesson independently at home and complete a learning worksheet. This worksheet was designed to collect information about the students' initial SLC. The collected data served as a baseline for evaluating changes in SLC throughout the experimental stages.

*During the experiment*: In this phase, students engaged in learning activities using the developed digital learning materials. After each learning session, students completed learning worksheets to provide data on the development of their SLC during the course. The use of digital materials allowed students to access information flexibly and created favorable conditions for them to take control of their own learning process.

*Post-experiment phase*: After the experimental phase ended, students continued to study new lessons at home and filled out the learning worksheet one final time. These worksheets were analyzed to assess changes in the students' SLC following the application of digital learning materials.

### 2.4.2. Information analysis and processing

The data collected from the learning worksheets were processed and analyzed using descriptive statistics and comparative analysis with SPSS software. Specifically, the results obtained from the three assessments (before, during, and after the experiment) were compared to determine the degree of change in students' self-learning competency. The evaluation criteria for SLC were analyzed using statistical indicators such as mean scores, standard deviations, and statistical significance tests, particularly the independent t-test, to identify meaningful differences between the stages.

In addition, the impact of using digital learning materials on the development of SLC was assessed through the effect size (ES) index. The criteria for evaluating self-learning competency include the ability to identify learning goals and content, the selection of appropriate learning methods and tools, the ability to collect and analyze information, and the ability to apply knowledge to solve learning situations. The calculation of effect size helped determine the effectiveness of the digital-material-based teaching approach in enhancing students' self-learning competency.

## 2.5. Results of pedagogical experiment

### 2.5.1. Current survey results

The survey results on the use of digital learning materials to develop self-learning competency among nearly 100 Chemistry students at Hanoi National University of Education, who took the course "Designing Chemistry Teaching Plans," show that the majority of students (78.9%) have participated in online courses or accessed digital learning resources. According to Figure 3, 77.8% of students consider self-learning to be essential, 20% consider it necessary, and only a small proportion (less than 1%) view it as average. About 73.3% of students prefer self-learning using digital learning platforms. Data from Figure 7 indicate that 98.9% of students rate the application of digital learning materials in developing self-learning competency as very important.

However, a significant number of students face difficulties during self-learning, such as being unable to create a study plan (51.1%), failing to follow the plan (61.1%), lacking someone to consult or guide them (56.7%), and other challenges illustrated in Figure 6. Several indicators of self-learning competency are shown in the charts below.

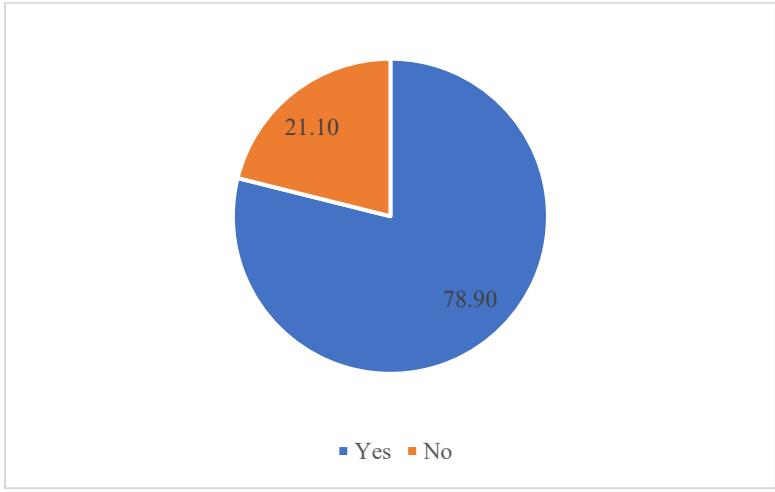


***Figure 2. Students participate in online courses or digital learning materials***

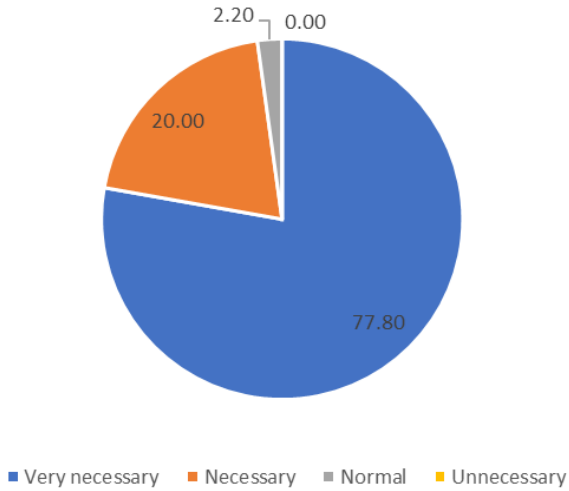


***Figure 3. Students rate the importance of self-learning***

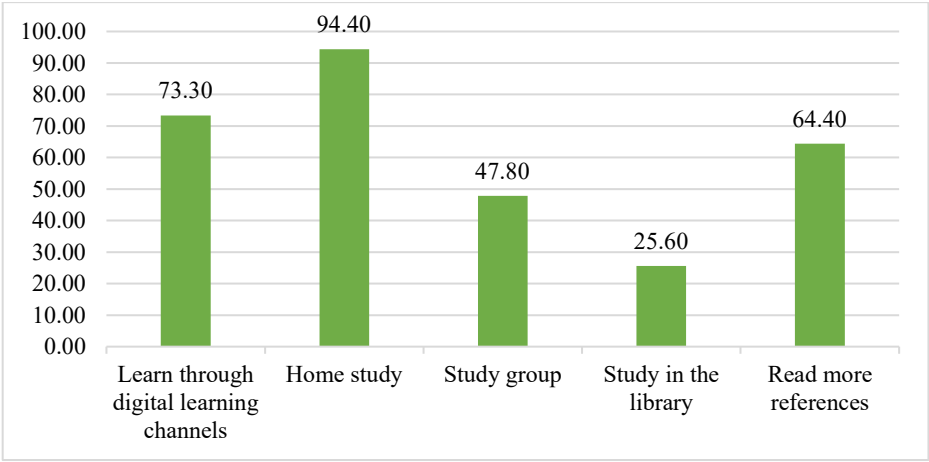


***Figure 4. Student self-learning form***

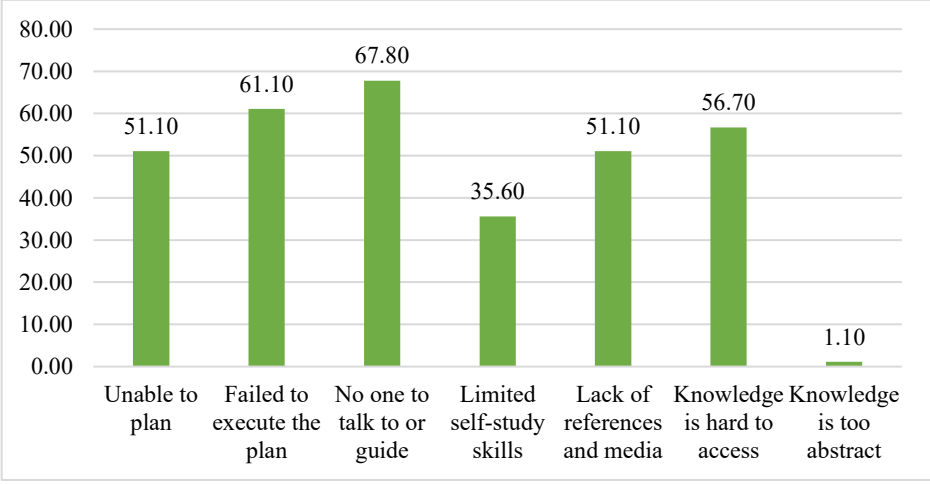


***Figure 5. Difficulties in the students' self-learning process***

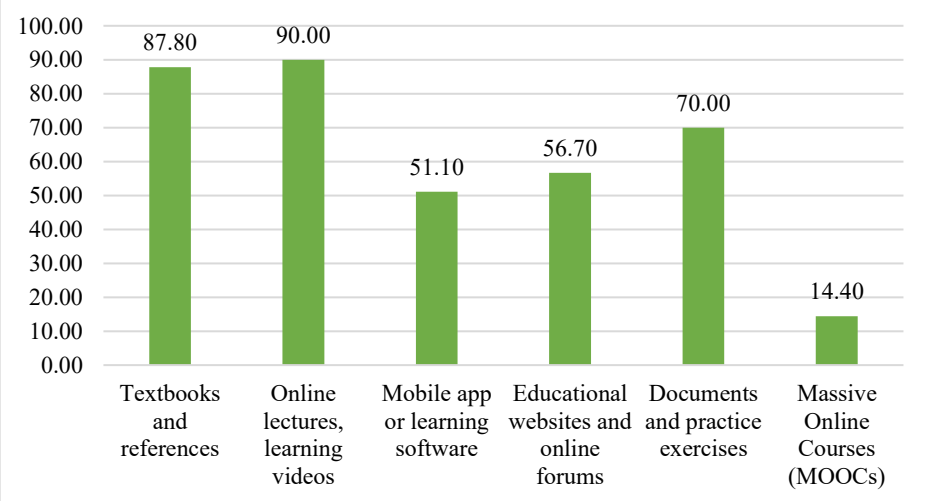


***Figure 6. Some learning materials to develop self-learning competency***

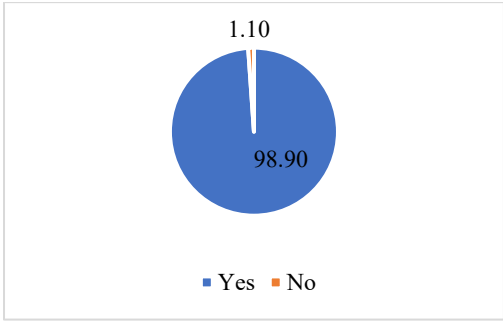


***Figure 7. Assessing the importance of using digital learning materials to develop self-learning competency***

**2.5.2. Conducting an experiment**

- Before the experiment: We assessed the SLC of students in the classes for the experiment by having them independently study a new lesson at home and complete a learning worksheet. The worksheets were then graded, and the average SLC score of the students was calculated.

- During the experiment: The developed digital learning platform was used to conduct the experimental teaching, and students were required to complete learning worksheets.

- After the experiment: Post-experiment SLC was assessed by asking students to independently study a new lesson at home and fill out the learning worksheet.

**2.5.3. Experimental results**

- Experimental results of 18 students of high-quality class K71C, Faculty of Chemistry, Hanoi National University of Education.

***Table 2. Comparing the levels of self-learning competency assessment of students in experimental class 1***

| Criteria | Before the experiment | | | | After the first experiment | | | | After the second experiment | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Number of students passing* | | | *Average score* | *Number of students passing* | | | *Average score* | *Number of students passing* | | | *Average score* |
| | **1** | **2** | **3** | | **1** | **2** | **3** | | **1** | **2** | **3** | |
| **C1** | 9 | 7 | 2 | ***1.61*** | 8 | 7 | 3 | ***1.72*** | 7 | 7 | 4 | ***1.83*** |
| **C2** | 12 | 4 | 2 | ***1.44*** | 10 | 5 | 3 | ***1.61*** | 9 | 5 | 4 | ***1.72*** |
| **C3** | 9 | 6 | 3 | ***1.67*** | 8 | 7 | 3 | ***1.72*** | 7 | 7 | 4 | ***1.83*** |
| **C4** | 8 | 8 | 2 | ***1.67*** | 7 | 7 | 4 | ***1.83*** | 6 | 7 | 5 | ***1.94*** |
| **C5** | 6 | 8 | 4 | ***1.89*** | 5 | 9 | 4 | ***1.94*** | 4 | 9 | 5 | ***2.06*** |
| **C6** | 10 | 7 | 1 | ***1.50*** | 8 | 8 | 2 | ***1.67*** | 7 | 8 | 3 | ***1.78*** |
| **C7** | 8 | 7 | 3 | ***1.72*** | 7 | 8 | 3 | ***1.78*** | 6 | 9 | 3 | ***1.83*** |
| **C8** | 8 | 7 | 3 | ***1.72*** | 8 | 6 | 4 | ***1.78*** | 8 | 6 | 4 | ***1.78*** |
| X | | | | 1.65 | X | | | 1.76 | X | | | 1.85 |
| *Standard deviation* | | | | *0.14* | *Standard deviation* | | | *0.10* | *Standard deviation* | | | *0.11* |
| *Paired T-test p* | | | | *0.000531357* | | | | *0.00022757* | | | | |
| *ES Impact Level* | | | | *0.752152085* | | | | *0.88* | | | | |

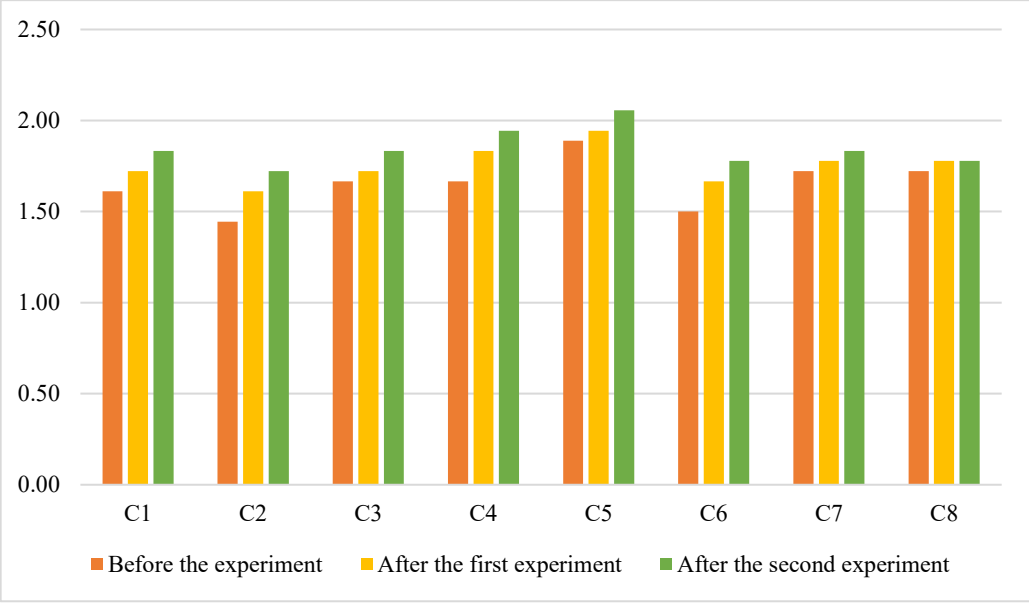


***Figure 8. Comparison chart of self-learning competency expressions before the test, the first test, and the second test of class K71C***

- Experimental results of 36 students of class K72, Faculty of Chemistry, Hanoi National University of Education.

***Table 3. Comparing the levels of self-learning competency assessment of students in experimental class 2***

| **Criteria** | **Before the experiment** | | | | **After the first experiment** | | | | **After the second experiment** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Number of students passing*** | | | ***Average score*** | ***Number of students passing*** | | | ***Average score*** | ***Number of students passing*** | | | ***Average score*** |
| | **1** | **2** | **3** | | **1** | **2** | **3** | | **1** | **2** | **3** | |
| **C1** | 19 | 12 | 5 | **1.61** | 17 | 12 | 7 | **1.72** | 14 | 13 | 9 | **1.86** |
| **C2** | 18 | 12 | 6 | **1.67** | 15 | 12 | 9 | **1.83** | 12 | 14 | 10 | **1.94** |
| **C3** | 16 | 13 | 7 | **1.75** | 16 | 10 | 10 | **1.83** | 15 | 10 | 11 | **1.89** |
| **C4** | 15 | 15 | 6 | **1.75** | 15 | 14 | 7 | **1.78** | 13 | 14 | 9 | **1.89** |
| **C5** | 18 | 10 | 8 | **1.72** | 16 | 9 | 11 | **1.86** | 15 | 10 | 11 | **1.89** |
| **C6** | 21 | 11 | 4 | **1.53** | 19 | 9 | 8 | **1.69** | 16 | 10 | 10 | **1.83** |
| **C7** | 24 | 9 | 3 | **1.42** | 22 | 9 | 5 | **1.53** | 20 | 9 | 7 | **1.64** |
| **C8** | 18 | 11 | 7 | **1.69** | 17 | 11 | 8 | **1.75** | 15 | 12 | 9 | **1.83** |
| X | | | | 1.64 | X | | | 1.75 | X | | | 1.85 |
| *Standard deviation* | | | | *0.12* | *Standard deviation* | | | *0.11* | *Standard deviation* | | | *0.09* |
| *Paired T-test p* | | | | *0.000254688* | | | | *0.000105777* | | | | |
| *ES Impact Level* | | | | *0.91019134* | | | | *0.908030413* | | | | |

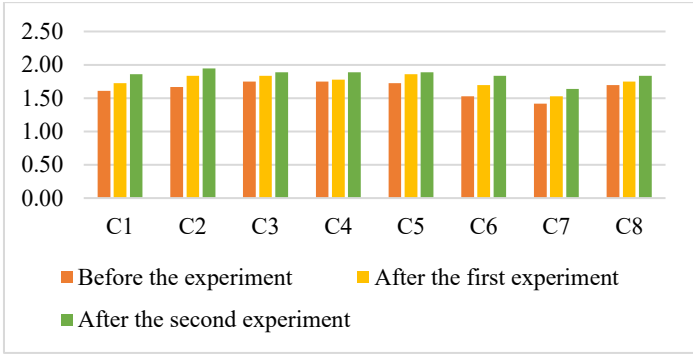


***Figure 9. Comparison chart of self-learning competency expressions before the test, the first test, and the second test of class K72.***

Through 2 charts conducted in 2 classes: class K71C and class K72, Chemistry department, Hanoi National University of Education, the results obtained are as follows:

The graphs in Figure 8 and Figure 9 show that the expressions in the two experimental classes of 18 students of K71C and 36 students of K72 all have increased values throughout the experiments. This can be explained by the fact that students rarely perform self-assessment activities during the learning process (according to the results of the current investigation that we have conducted). On the other hand, the p-values of the T-test verification for class K71C are 0.0005, and 0.0002 (Table 2), and the values for class K72 are 0.0002, 0.0001 (Table 3), which are less than 0.05, showing that the differences in average scores before the experiment, after the first experiment and after the second experiment in both classes are significant. That means that the development of students' SLC does not happen randomly but is due to impact.

The level of influence, according to Cohen's criteria, is quite large (ES = 0.75 to 0.91). Thus, the proposed measure has developed students' SLC significantly. This confirms the effectiveness and feasibility of using digital learning materials built according to the digital learning material model in developing SLC for students of the Faculty of Chemistry - Hanoi National University of Education.

Although the research results show significant improvements in SLC after the application of DLMs, a deeper analysis of each component of SLC is necessary to clarify the influence of each element. Specifically, criteria such as the ability to determine learning goals and content, the ability to collect and analyze information, and the ability to evaluate learning outcomes have shown significant improvement. However, the extent of improvement for each factor should be analyzed in more detail to better understand how DLMs impact these skills.

Additionally, compared to previous studies on the development of self-learning competence, this study demonstrates the superior effectiveness of DLMs in fostering self-learning skills, particularly in motivating students to engage in self-learning and enhancing self-regulation. Comparing these results with traditional teaching models and international research will help highlight the differences and advantages of this approach in the context of modern education.

## 3. Conclusions

Experimental results show that using digital learning materials develops students' self - learning competency. Specifically, the findings demonstrate that students' ability to define learning goals, select appropriate methods, and assess their learning outcomes all show significant improvement ($p < 0.05$). These results confirm that DLMs are an effective tool in enhancing self-directed learning in the context of chemistry education. On that basis, teachers can adopt and apply it to students nationwide, especially in training institutions with suitable facilities. However,

for this model to be effective, teachers need to build a rich and diverse source of learning materials to stimulate students' self-learning motivation; use a reasonable and flexible teaching process; pay attention to the conditions for students to use computers and smartphones with internet connection, so that the process of using learning materials is optimally effective. In the process of building digital learning materials, teachers need to prepare lectures, tests, video lectures, etc., to serve the teaching process in class, to develop the self-learning competency for all students through online lectures, and enable them to study anytime and anywhere.

***Acknowledgements.*** This research was funded by Hanoi University of Education through the basic project with the code SPHN23-16.

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