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Designing learning activities to develop self-directed learning competency in teaching informatics

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ABSTRACT

Currently, there are not many studies on teaching informatics in the direction of developing students' self-directed learning (SDL) competency. The results of the survey with 235 informatics teachers in 42 provinces/cities across Vietnam showed that although they are very interested in teaching SDL, teachers are still confused about teaching methods and assessments. To improve the effectiveness of informatics teaching as well as develop SDL for students, the study proposed a method of teaching informatics in the direction of designing activities to guide students to create digital products by themselves. The pedagogical experiment on assessing SDL and learning outcomes was conducted on two experimental and control groups, selected from 87 10th grade students, in the first semester of the school year 2022-2023 at Cam Giang High school in Hai Duong, Vietnam. The results of SDL and test scores of the experimental class were higher than that of the control class (with p-value <0.005– this difference is statistically significant). This proves that the method (creating of digital products) is effective, positively affecting students' learning, helping students develop SDL competency.

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1. INTRODUCTION

With the development of the internet, an extremely large amount of information is generated every day, the problem is not only simply receiving information, but also needing to know how to evaluate and select information. The ever-changing world requires students to solve complex problems, and not simply find answers in textbooks. Therefore, self-directed learning (SDL) and lifelong learning along with the ability to adapt in a dynamic world are essential. Learners consider themselves to be their own teachers, without the need for guidance or help from others – the initial definition of SDL [1]. In other words, SDL describes a process in which individuals take the initiative, with or without the help of others, in identifying their learning needs, formulating learning goals, identifying determine human and material resources for learning, select and implement learning strategies, and evaluate learning outcomes appropriately [2].

In the world, general theoretical studies on SDL and SDL competency consider people with self-learning ability to have persistent learning motivation, independence, discipline, ability to define goals and have appropriate study skills [3]. Whether studying or practicing, studying individually or in groups, each individual learner will have a unique method and ability [4], [5]. Researches on the evaluation framework of renewable energy and measures to develop renewable energy focus on one evaluation criterion and seek to describe it through the manifestations of SDL, such as: focusing on the evaluation criteria "readiness for self-

study" [6] and focusing on measuring "readiness for self-study" [7]–[9]. Studies on the role of information and communication technology (ICT) in self-study have appeared in recent years. In the era of constantly changing technology, students need to have the necessary knowledge, skills and orientation to be able to learn and teachers need to support students in SDL with the application of technology in the classroom [10]–[12], motivation in informal learning from online learning systems [13], [14].

In Vietnam, research on SDL is also diverse and inherits from studies in the world, spreading at many levels and fields. Including overview studies on learning such as SDL - a need of the times [15], analysis of the process of teaching - SDL [16], considering teaching as a golden key of education [17], [18]. Studies also suggest measures to develop SDL abilities for students through teaching a number of specific subjects [19]–[25]. Although there are different research directions, the common point of the previous studies is that they all inherit the theoretical bases of mathematics and offer measures to develop mathematical competency for students through teaching a number of subjects, such as mathematics, chemistry, literature. Among the existing studies in Vietnam, there is only one study [26] on the development of SDL competency for students in teaching informatics. However, this study is only the first step with general solutions for development, not going into details about a measure as well as evaluating its effectiveness.

From the aforementioned comments, we have proposed some methods of teaching informatics to develop SDL competency for students and have successfully experimented. In this study, we use the concept of SDL in the view of Knowles [2], "SDL describes a process in which individuals take the initiative with or without the help of others, in identifying their learning needs, formulating learning goals, identifying human and material resources for learning, selecting and implementing learning strategies, and assessing learning outcomes appropriately." From this concept, it can be shown that self-efficacy includes the following component competencies: i) Self-determination of the needs for learning (or having a need for experimentation), that is, having the desire, the motivation to learn and the desire to enjoy their own learning process; ii) Self-determine learning goals, including external goals (mandatory) and internal goals (voluntary, apperception, needs); iii) Self-determination of resources, which are environmental factors that play a role in determining learning, such as learning resources, learning support and learning context; iv) Self-determination of learning strategies, including self-determination of learning goals, objectives and tasks, self-determine learning methods (in class, at home), self-determining timetable (time to learn compulsory knowledge, time for self-discovery, time for daily activities); v) Self-assessment, including self-assessment of the learning process (process assessment/regular assessment), self-assessment of how learning is going.

Within the scope of this article, the study focused on presenting the current situation of teaching informatics in the direction of developing SDL competency for high school students and present a method. It is the design of learning activities of teachers to guide students to create digital products by themselves - a specific informatics learning activity, thereby fostering and developing SDL competency. The article also presents experimental results for comparison and evaluation between the experimental group (teachers apply self-directed learning activities) and the control group (teachers organize teaching in the traditional way).

2. RESEARCH METHOD

This study uses a mixed method including theoretical and experimental research, using qualitative and quantitative methods for analysis and evaluation. The research process was carried out through two steps. First step is survey of informatics teachers from different high schools in Vietnam was conducted in the first period of the school year 2022-2023. The content of the survey focused on the main issues: i) teachers' perception of the role of teaching Informatics in the direction of developing SDL for students; ii) assessing the level of manifestation of students' SDL competency in informatics subject; iii) difficulties in teaching informatics to develop SDL competency for students.

Second step, proposing the method of teaching informatics to develop SDL for students is "Designing learning activities to guide students to create digital products by themselves." This method was conducted experimentally in the first semester of the school year 2022-2023. Survey data collected by questionnaire and test results were processed and analyzed using Microsoft Excel 2016, STATA 12 software to evaluate the effectiveness of the method.

3. RESULTS AND DISCUSSION

3.1. Pre-research survey results

We have conducted a survey of 235 teachers in 42 provinces/cities across Vietnam about the current state of students' computer literacy. For teachers' awareness of the role of teaching informatics in the direction of developing SDL, up to 87.7% of teachers participating in the survey are interested at a high and very high level (level 4, 5 on a scale of 5), according to Figure 1.

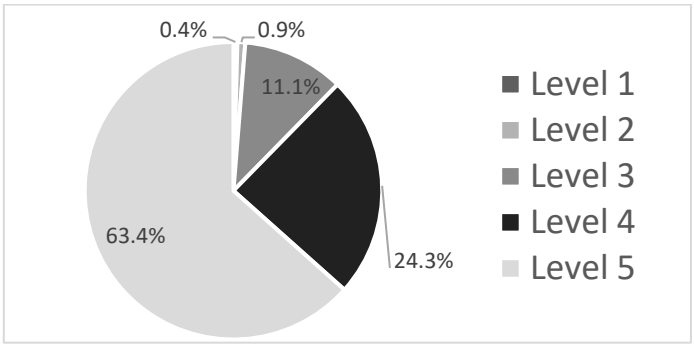

Figure 1. Assessing teacher's perception of the role of teaching informatics towards developing SDL

According to five criteria for assessing SDL for students [26] (ability to define goals, ability to plan in learning, self-determination of learning resources, self-determination - implementing strategies and ability to self-assess assessment), the teachers participating in the survey assessed the status of students' SDL at medium and low levels (levels 1, 2 on a scale of 3). Figure 2 shows that the average level of awareness accounts for 59.6%-76.8%, the level of good awareness only accounts for 9%-11%, especially the ability to identify resources has up to 29% of teachers participating in the assessment. Student prices are at a good level, possibly stemming from the popularity of the internet and early access to information technology (IT) by students. Also, according to the survey results, the teachers divided the difficulties in teaching to improve the SDL competency for students into four main groups, in which the outstanding difficulty was related to the lack of appropriate measures to teach to develop the SDL for students with 41.3% choosing difficult and 22.6% choosing very difficult as shown in Figure 3. For proposals related to the necessary support to improve students' SDL, the support for teaching methods accounted for 44.7%, assessment methods for 11.9% as displayed in Figure 4.

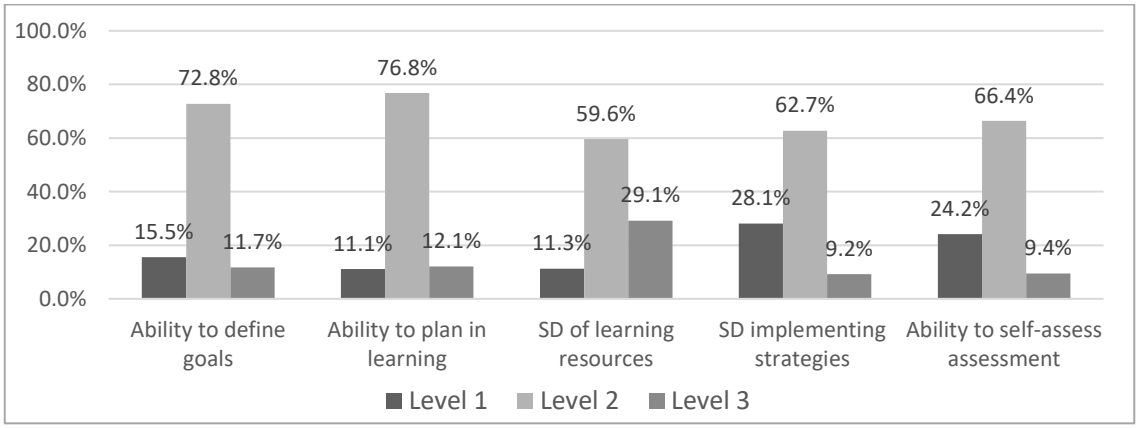

Figure 2. Evaluate students' SDL according to five criteria

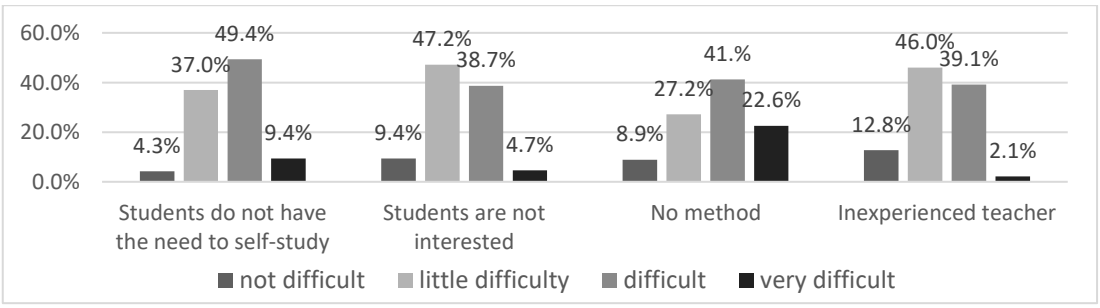

Figure 3. Difficulties in teaching to improve students' SDL

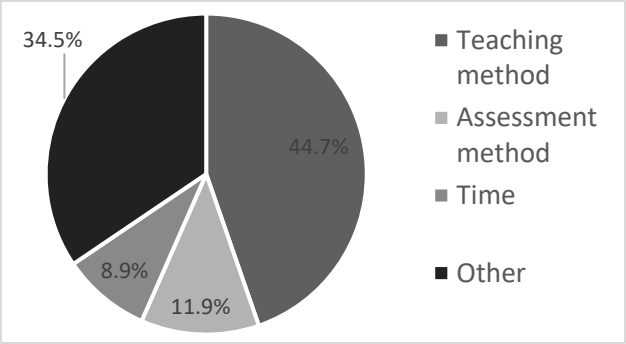

Figure 4. Proposal to support teaching to improve students' SDL

3.2. Designing activities to guide students to create digital products by themselves to develop SDL competency

3.2.1. Scientific basis of the solution

The main scientific basis of the solution is derived from the rules of competency development in general and SDL development. Competency is the "personal attribute formed and developed by the inherent qualities and the learning and training process, allowing people to synthesize knowledge, skills and other personal attributes such as inspiration, pleasure, belief, and will to successfully perform a certain type of activity, achieving the desired result under specific conditions" [27]. To develop competency, students need to study and practice with the guidance of teachers from goal orientation, content, learning tasks to learning path. With SDL, the teacher's guidance needs to be "gradually withdrawn" from guiding students to self-study until students can learn completely by themselves. Therefore, teachers need to design learning activities to direct students from learning habits according to the teacher's transmission to active learning with orientation and towards independent self-study.

The characteristic of Informatics subject is to create digital products (presentations, videos, posters, programs on computers). So, to develop SDL competency for students, while teaching Informatics, teachers need to create learning activities that give students the ability to apply knowledge and skills to create products for practical needs. Learning activities designed by teachers should give students the opportunity to demonstrate their digital products, edited based on positive feedback from teachers and friends. This gives them confidence and pride and motivates them to continue learning to create more complete products. From there, there is motivation, the need to learn better (one of the internal factors affecting self-study).

The created learning activities need to promote students' cognitive skills so that students must self-determine the content of digital products, the product implementation process as well as require students to learn and research more sources themselves. resources on the internet. This will help foster students' attention, memory, note-taking, and information-seeking skills. These are important skills of SDL and are also necessary skills of informatics subject. Learning activities are designed to give students the opportunity to "connect" what they learn to create digital products, and then are required to continuously "practice retrieving" things learned it in the process of creating the product. "Learning what connects that" and "practicing access" are two necessary factors for developing students' learning skills [28].

Teachers need to create for students an environment of extended time and space. Students need to be able to learn outside the classroom and take the initiative in learning time. Students also need to be proactive in finding resources from the internet in addition to the resources suggested by the teacher. Attention should be paid to creating a "peer" environment for students. Therefore, learning activities should be designed in groups, so that students could assign work in groups, everyone is responsible for his or her own work and participates in the common work of the group. must self-assess each other. Thus, students need both support and "competition" to create motivation for them to learn on their own to complete their tasks [29]. The environmental factors of time, space, reference resources, and "peer" environment are the external factors [30] that affect students' SDL.

3.2.2. Content and how to organize the implementation of solution

a. Content of solution

To guide students to create digital products by themselves, teachers design a learning task with several characteristics. Firstly, the learning task is to create digital products and related requirements. Teachers need to create and transfer learning tasks to students. The word "transfer" implies turning "teaching goals" (teachers help students create digital products) into "learning goals" (students want to create digital

products). To do this, teachers use the method of motivating learning in informatics for students. The best way to motivate students is to make students see that the learning task is beneficial to them, for example, being able to create their own postcards for relatives or friends. The second-best way is to make students see that performing the learning task is their responsibility to family, friends, school, or society, for example, it is necessary to create propaganda posters about prevention of COVID. There are fewer good ways, such as making students excited, for example: the graphic product to be created is a challenging but very attractive task, very "conquering".

Secondly, the learning task takes a long time to perform. The learning task is designed so that it requires students to have long-term learning activities, so that the student's learning activities have enough time to change. In the direction of increasingly "depending on themselves", so that students form the habit of SDL. The digital product in a learning task that requires a long time to implement is not necessarily a digital product, but it takes a long time (many lessons) to complete, it can be digital products individually in each lesson, a series of digital products of an Informatics topic (from intermediate products to the target product to be created), a product of informatics project.

Thirdly, students need to identify goals and criteria for assessing learning outcomes. Learning goals must satisfy two conditions: i) on legal conditions, learning goals must be oriented by goals. information technology education goals, specified in the topic/lesson; ii) on conditions to promote self-study, learning goals need to satisfy students' requests or needs and interests. To satisfy the legal conditions, the teacher "suggests target-oriented motivation". To satisfy the conditions to promote self-study, the teacher let the students choose the digital products they want to create. Similarly, the activity of determining criteria for assessing learning outcomes, specifically here the criteria for evaluating digital products, is also organized by teachers for students to participate in building on a product evaluation framework. products prepared by the teacher in advance. When evaluating digital products, there are two stages: evaluation of the product creation process and evaluation of product creation results. In short, in the self-study guide, the goals and criteria for evaluating digital products are organized by teachers for students to participate, so that they can commit themselves and take responsibility for their learning results

Fourth, students are guided to make their own learning plans. To create a learning plan for making digital products, students need to be guided to use the software to make and manage the task plan. Tasks include identifying learning tasks, learning resources, and learning strategies. The plan is not simply a timetable of digital product creation tasks, but also demonstrates the exploitation and use of time science in and out of the classroom, with reference resources from teachers such as learning materials, websites. With the characteristics of Informatics subject to study with computers and often use the Internet, students will be easily distracted in the process of performing tasks with other applications and software. Therefore, making and managing the implementation of specific plans by software will help students complete individual tasks based on the general schedule of activities in terms of time and duration given by the teacher.

Fifth, students are given the opportunity to edit the task process and digital products created based on positive feedback. During the student's performance on the task, students should have the opportunity to modify the products. its products especially CS digital products. Before students start creating computer programs, teachers' feedback on the product creation process such as designing and choosing the right algorithm is essential to having a correct program. Like ICT digital products, students need feedback and adjustment during the product making process to achieve the best results according to the set criteria. The feedback teachers give should clearly indicate to students, specifically i) what students are doing well, what needs to be modified (for example, is such working time appropriate, is the work assignment reasonable?); ii) relate the assessment goals and criteria to provide the missing score; iii) help students realize their own progress in the learning process; iv) help students perform the reflection step after completing the activity. Along with platforms that support IT collaboration such as Padlet, Teams, Jam board, teachers will be able to monitor the process of students making products and give instant feedback when students need it.

Lastly, students are organized to reflect on their own learning process. Reflection is an activity for students to reflect on the performance of the activity as well as their own learning. Teachers need to guide students to reflect by asking questions such as: What are your strengths? What is the point to improve (about the set goal, about the implementation plan, about what knowledge and skills need to learn more); Which learning method is best for you? Is the goal you set at the beginning achievable and appropriate? The process of students performing tasks to create digital products showing that students are inclined towards CS or ICT are two characteristic orientations of informatics. Self-reflection will help students realize their own inclinations, thereby motivating them to continue self-study, self-study according to their own inclinations, promoting their strengths and improving their weaknesses. For example, students do very well with digital products such as posters and videos but are limited when asked to create computer programs. This proves that students are more capable of ICT than CS and vice versa. Students can create reflections on planning software or with tools like Canva, Notion. The use of software will help students save their entire learning history, thereby improving their learning better.

b. Organize the implementation of solution

There were several steps to design learning activities to guide students in self-study. The first step is select the content of informatics knowledge and the appropriate form of digital products for students to learn. The appropriate knowledge content to build learning activities to develop self-study for students should be the parts that students are able to find out on their own in textbooks and look up information on the internet. The right digital product form is usually a presentation, poster, or video. The appropriate way to design students' learning activities is to use teaching methods to develop self-study competency in theories of learning such as teaching discovery and solving problems, teaching programming, teaching based on learning case. Besides, teachers should use external influences (rewards and recognition) to motivate students to learn.

Second step is build activity, where teachers need to design learning activities to ensure that activities are long enough for students to build their own learning goals, self-planning, self-monitoring and adjusting their learning activities based on feedback of teachers, classmates, and other related subjects. Lastly, check the elements to ensure satisfactory operation. To assess whether learning activities create conditions for students to develop self-study, teachers can use the decision tree in Figure 5.

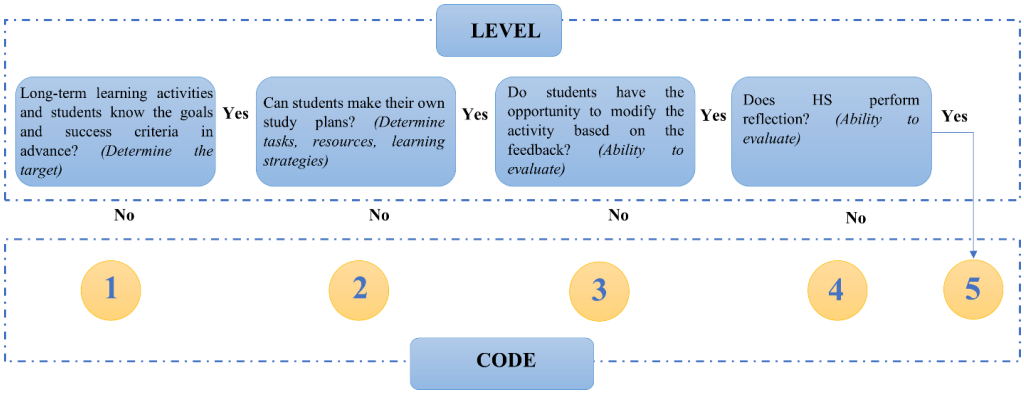

Figure 5. Decision tree model to determine the code of learning activities to develop mathematical intelligence for students

Teachers need to check whether the learning activity they have designed is a long-term task, and whether the students know in advance the goals (set by the teacher and self-determined specific goals) as well as the objectives (evaluate). Otherwise, this works only in code 1 and needs editing to be better. If yes, does the teacher continue to check if this activity allows students to make their own plans? Otherwise, this works only in code 2 and needs editing to be better. If yes, does the teacher continuing to check this activity give students the opportunity to edit the work based on the feedback? This product modification is not only editing the final product, but also editing at different stages of the student's task, such as editing goals, specific tasks or editing the actual plan. currently, preliminary blueprints. Otherwise, this activity is only in code 3 and needs tweaking to make it better. If yes, does the teacher continue to check if the activity allows students to reflect on their own? If not, the activity needs editing to be better. If yes, this activity has reached code 5, the highest code of learning activities to develop self-study for students.

3.3. Experimental results

We experimented with the method in two classes (experimental class and control class) at Cam Giang High School - Hai Duong, Vietnam with a total of 87 students. The experimental class (10M) was taught according to the proposed method while the control class (10L) studied by the conventional method. The self-efficacy of each student is monitored and evaluated in three ways: i) the scale is assessed by the students themselves; ii) the scale is assessed by the teacher; and iii) the class test.

The students scale includes 33 questions divided into five groups corresponding to five manifestations of self-efficacy. In order to limit random selections, unintentional selection or selection of all results that skew survey data, for certain questions we have built test questions, ask for adjustment. The results of the selection of test questions are not included in the survey results, but are used to adjust the questions to be surveyed. The teachers scale includes 18 questions divided into five groups corresponding to five manifestations of competency. The test score is the test score at the beginning of the year and at the end of the term informatics subject of each class, the test score is the scale reflecting the cognitive ability of the students.

3.3.1. Input test

The two experimental selection classes are equivalent in level based on the entrance exam scores and the assessment of the teacher's judgment. To retest the equivalence of the two classes, we use the t-test for each student's input assessment results. All three methods are shown in Table 1 that the mean score of the control group and the experimental group had no difference with p>0.05. Thus, it can be said that the self-study scores of the two groups before the experiment are equivalent.

Table 1. The results of self-assessment of the control and experimental groups

Group type	N	The students scale			The teachers scale			The test score		
		Mean	SD	p	Mean	SD	p	Mean	SD	p
Control	43	3.34	0.08	0.7589	1.46	0.04	0.3120	7.86	0.06	0.3092
Experiment	44	3.37	0.05		1.40	0.04		7.95	0.06	

3.3.2. Output test

a. Evaluate the level of change between two groups

In order to assess the extent of change in students' SDL following the experiment, a statistical analysis was conducted by utilizing the t-test. This test was applied to compare the average output scores of the two distinct groups under consideration. The outcomes of this analysis are graphically represented in Table 2, offering a visual representation of the observed differences in the self-study abilities between the two groups post-experimentation.

Table 2. Test the average output rating by group and survey time

Group type	N	The students scale			The teachers scale			The test score		
		Mean	SD	p	Mean	SD	p	Mean	SD	p
Control	43	3.49	0.05	0.0018	1.65	0.05	0.000	8.14	0.07	0.009
Experiment	44	3.71	0.04		2.00	0.05		8.42	0.08	

For the average score of the output assessed by the students themselves, the average score of the output of the experiment group is higher than that of the control group (average 3.71±0.04 versus 3.49±0.05), the Statistically significant difference with p=0.0018. For the average score of the output assessed by the teacher, the average score of the output of the experiment group is higher than that of the control group (average 2.00±0.05 compared to 1.65±0.05), the difference statistically significant with p=0.000. For the final test score, the final test score of the experimental group was higher than that of the control group (average 8.42±0.08 compared with 8.14±0.07), the difference was statistically significant with p=0.009. Thus, all three methods of assessment gave consistent and positive results. After the teaching process, the experiment group had better scores than the control group. The difference was statistically significant with p<0.05.

b. Assess the degree of change by group

The assessment of students' SDL competency has been categorized into four distinct levels, each aligning with specific score ranges designated for every assessment method. These levels serve as a comprehensive framework to evaluate the extent of change in SDL competency exhibited by each group before and after the experiment. To facilitate a clear understanding of these changes, the results are visually represented in Figure 6(a) and Figure 6(b). Further, Figure 7 shows the average score test.

Upon a careful examination of the graphical representation, it becomes evident that there is a noteworthy trend observed across all three evaluation methods. Specifically, the experiment group consistently exhibits significantly higher average scores denoted as "EXP_after" at the highest level, which is level 4, post-experiment. This consistent increase in scores across various assessment methods underscores the notable positive impact of the experiment on the group's performance, emphasizing the effectiveness of the intervention in enhancing their overall competence at this advanced level of proficiency.

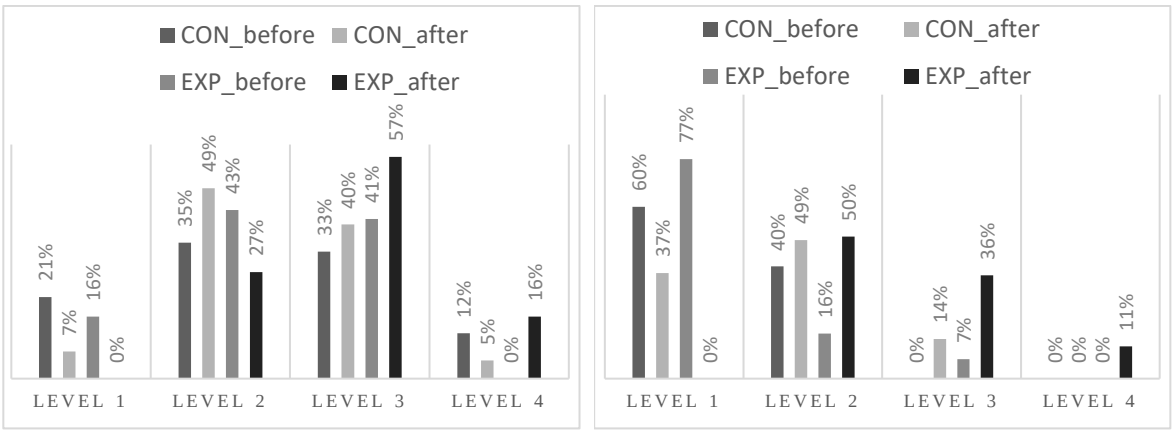

Figure 6. The average score assessed by (a) students and (b) teacher

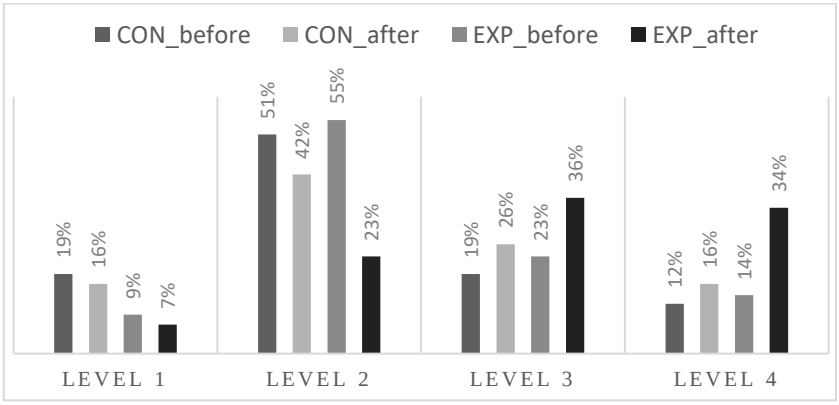

Figure 7. Average test score

3.4. Evaluation after experiment

In order to have a preliminary view of students' interest and interest in the lesson after applying the measure, we conducted a survey for students in the experiment group. Up to 100% of students support continuing to maintain innovative learning methods and 95.4% of students show a high and very high interest in learning methods (4-5/5) as presented in Figure 8. Most of the students agreed that the learning method had a positive impact on themselves (expanding knowledge of informatics, gaining knowledge associated with the real life, enhancing interest in the subject).

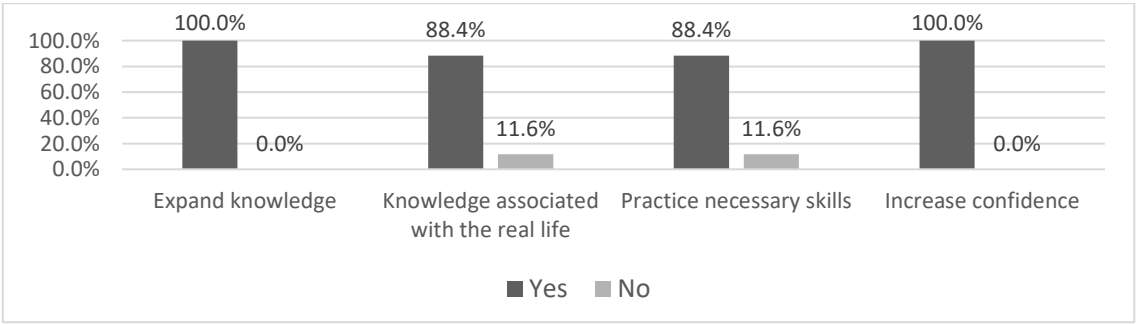

Figure 8. Student survey results after the experiment

The results from this survey and the score of students obtained include the following statements: i) guiding students to create digital products by themselves can expanding knowledge of Informatics and the knowledge is associated with the real life; ii) guiding students to create digital products can enhance necessary skills for learning (teamwork, searching information, problem solving, creating digital products, present); iii) guiding students to create digital products can increase interest in learning Informatics and more confidence when standing in front of a crowd; iv) students are more motivated to learn; v) students know how to identify learning goals and tasks, plan, develop and implement a reasonable learning strategy and self-assess their learning.

The results derived from this study provide compelling evidence that students who were exposed to the innovative teaching approach demonstrated superior achievement scores and a heightened level of self-directed learning competency when compared to their counterparts who underwent traditional teaching methods. These findings underscore the potential benefits and effectiveness of adopting this teaching technique, which involves designing learning activities aimed at guiding students in the creation of digital products. In light of these results, it is strongly recommended that informatics teachers in high schools across Vietnam consider incorporating this approach into their curriculum, as it holds the promise of fostering and further developing SDL competencies among their students, ultimately contributing to their overall educational success and growth.

4. CONCLUSION

Theoretically, this study proposes an appropriate measure to teach informatics in the direction of developing self-studying capacity for students. Those are the principles and processes for teachers to design activities to guide students to create digital products themselves, thereby helping them develop their own self-efficacy, adapting to the constantly changing digital technology environment like nowadays. In terms of practical contributions, the study has provided an analysis of the current situation of teaching informatics with a specific assessment of students' self-efficacy expressed in the subject of Informatics. This is the basis for other studies on the development of self-directed learning competency for students in general and through teaching informatics in particular. This study also provides references on the scale to assess the SDL level of students in informatics subject so that teachers can "measure" students' SDL competency, supplementing documents to build a system supporting teaching and learning to help improve the self-efficacy expressed in Informatics for students.

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