Exploiting the Digital Environment to Teach Informatics in the Direction of Developing Self-directed Learning Competency for High School Students in Vietnam

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***Abstract*—The development of information technology and the internet has introduced various forms of learning, including blended learning, which has become increasingly important for high schools which are looking to modernize their classrooms and overcome the constraints of time and space. While there have been numerous studies on blended learning in different subjects, most research has focused on using this approach to develop common competencies among students and improve learning outcomes. This study demonstrates the effectiveness of using a blended teaching method to develop self-directed learning competencies in Informatics by leveraging the digital environment. The proposed blended teaching process for teaching digital content in Informatics consists of three phases: before, during, and after class. In the first semester of the 2022–2023 academic year, an experimental group of 45 students at HoaiDucB High School in Hanoi were taught through a combination of classroom instruction and an online learning system, while the control group of 45 students were taught using traditional methods. The findings reveal that students taught with the blended method exhibited higher levels of self-directed learning competency and achieved better learning outcomes compared to the control group (with a p-value of <0.005). Additionally, a post-experiment survey revealed that students were satisfied with this innovative learning method and were more actively engaged in their studies.**

***Index Terms*—Blended learning, teaching informatics, self-directed learning competency, teaching to develop competency**

I. Introduction

The rapid development of Information Technology (IT) has facilitated various forms of learning through the internet. The term "E-Learning" refers to online learning, which is becoming increasingly popular. In high schools, E-Learning is not used separately from face-to-face learning but is combined to achieve optimal learning efficiency. This learning model is called blended learning (B-learning) and has been researched and implemented in many parts of the world, including Vietnam.

In addition to general studies on the basics of B-learning [1], there is also interest in using B-learning for teaching computer science [2–5]. Studies have shown the advantages, disadvantages, and some difficulties when implementing B-learning in teaching [6, 7]. Many researchers have also discussed the problems and future challenges for B-learning [8–10]. In Vietnam, research on B-learning focuses on general topics [11], as well as applying this model to teach specific subjects such as Physics [12, 13], Chemistry [14], and Information Technology for college and university students [15, 16].

In general, studies have shown the effectiveness of B-learning in teaching to develop students' competencies. However, there have not been any clear and specific assessments of what competencies are developed and how they are developed.

The ever-changing world requires students to solve complex problems, rather than simply finding answers in textbooks. Therefore, self-directed learning (SDL) and lifelong learning, along with the ability to adapt in a dynamic world, are essential

Research on self-directed learning (SDL) has existed for a long time and is very rich and diverse, with three main research directions: Firstly, an overview theory of SDL and SDL competencies such as concepts, expressions, models, and influential factors, with typical authors such as Tough [17], Knowles [18], Taylor Bob [19], and Sandra Kerka [20]; Secondly, the evaluation framework of SDL and measures to develop SDL competencies [21–23]; Thirdly, the role of Information and Communication Technology (ICT) in the development of SDL [24–26].

Although studies are diverse, there has not been any research examining the use of the B-learning model to teach Informatics and develop SDL competency for students, with an evaluation of the model's effectiveness. Therefore, in this study, we propose a blended teaching process suitable for teaching Informatics in high schools to develop SDL for students and evaluate the effectiveness of this teaching method. The study aims to investigate whether students' learning outcomes in blended learning are better than those in face-to-face learning, and to determine whether there is a positive correlation between students' SDL and blended learning. We also want to understand students' perceptions of experiencing blended learning.

II. Methods

A. Design of the Study

This study proposes a blended teaching process in Informatics that is suitable for the development of SDL competency for students. The main scientific basis of the proposal comes from the orientation that needs to affect external factors affecting SDL [27]. The external factors mentioned here include the *time environment*, which is one of

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the important influencing factors for students' SDL awareness. Students need to learn in an environment that is not limited in time like the traditional learning model. They should be free to choose the start and end time of the learning task, which will help them have more time to carry out their learning activities in accordance with their level and interests. Learning about computers (Informatics) and by computers (supporting learning Informatics and other subjects) requires students to ensure enough time to be able to learn and discover knowledge by themselves. It is also important to take a break every time they sit at the computer, for example, taking a 15-minute break every 45 minutes. Such time limits will motivate students to have an SDL plan to be able to complete their learning tasks. With the *physical environment*, students need to be able to expand the classroom space to the outside where they can take advantage of resources such as personal computers or smartphones to aid their learning. Along with that, students need an environment where they can access a lot of *reference resources* with resource orientation from teachers. In addition, students can also search and select resources on the internet by themselves to support their learning and improve their skills in using learning resources

Informatics is a subject that requires a significant amount of practice time. At the high school level, 50% of practice hours are devoted to ICT orientation and 35% of practice hours are focused on Computer Science (CS) orientation. In a large class, not all students can follow the teacher's modeling instructions on the projector, nor do they have ample opportunities to practice their skills, especially with topics related to ICT or problem-solving using computers. Thus, teachers must harness the digital environment to teach these contents. Furthermore, the SDL time is one of four factors identified to have a considerable influence on students' SDL awareness, as per survey results with over 1000 high school students [28]. Hence, having a learning environment that is available anytime and anywhere can significantly increase students' SDL time.

Along with the impact on external influencing factors, the proposed measure also needs to pay attention to the internal influencing factors [29], as well as the role of teachers in guiding students.

- **Creating motivation and learning needs:** It is necessary to create an environment for students to monitor their own learning process and realize their progress. When students perform their learning tasks, answer questions, or do exercises, and receive immediate feedback from the system, they will be motivated to continue learning. This is one of the factors that help students have self-learning motivation from within, which is controlled by needs, interests, or interests arising in the implementation process. In the stages of learning outside the classroom, teachers need to base their approach on the process of students performing tasks to praise, motivate and support them in a timely manner, and point out their progress or mistakes in a skillful way. This ensures students always feel interested, active, and excited in learning. Teachers can offer rewards that match the needs of students, such as adding points to tests, assessing progress, or sending letters of praise or honor to students on the forum of the class or school. These are the effects that create learning motivation from outside for students. During class time, teachers need to organize opportunities for students to share what they have learned and done by themselves, such as presenting a new algorithm or a shorter program than the existing one. Self-expression is also one of the factors that create motivation and learning needs for students.
- **Promoting cognitive skills:** Teachers need to assign learning tasks to students that help them develop the skills to identify goals, plan their learning, and balance their time spent on different subjects. Additionally, students should be encouraged to develop their attention skills while researching and studying materials, and recording what they learn. These are necessary factors that promote the development of students' cognitive skills.
- **Promoting metacognitive skills:** Teachers should provide materials in advance for students to learn and research on their own, instead of just following the instructions of the teacher in class. This helps to change the way children learn. Instead of having to study according to the general progress, listen to lectures and take notes or work according to the teacher's organization, students are free to choose their own learning style. Since each student will like to learn in different ways, learning materials should be diverse, such as videos, lectures, and multiple-choice questions. Performing this learning task by themselves also helps students to be actively engaged in "connecting" the knowledge they have learned or "practicing in accessing" [30] that knowledge. These are two important factors to develop learning skills for students.

On that basis, a blended teaching process is proposed as suitable for digital content covering two knowledge areas: ICT and CS, and including three stages: before class time, during class time, and after class time. The specifics are outlined in Table I and Table II.

TABLE I: ACTIVITIES OF TEACHER AND STUDENTS IN THE BLENDED TEACHING PROCESS FOR ICT

Stage	Teacher's activities	Students' activities
Before class time	• Select appropriate content. • Determine the neccesary learning materials. • Upload them to LMS. • Assign tasks for students.	• Identify goals and learning tasks. • Engage in SDL.
During class time	• Check students' performance on tasks at home. • Organize activities for students. • Review lesson content and assign homework.	• Implement interactive learning activities under the guidance of teachers.
After class time	• Grade, correct and create statistics for students' learning results. • Reward and remind students as needed.	• Consolidate knowledge and skills through practice. • Monitor progress through regular reports. • Engage in self-assessment to reflect on the learning process.

TABLE II: ACTIVITIES OF TEACHER AND STUDENTS IN THE BLENDED TEACHING PROCESS FOR CS

Stage	Teacher's activities	Students' activities
Before class time	• Determine the neccesary learning materials. • Upload the materials to the LMS. • Assign tasks to students. • Provide a self-study guide for students	• Identify learning goals and tasks. • Preview the lesson materials
During class time	• Use active teaching methods to guide student learning. • Organize activities for students. • Review lesson content and assign homework.	• Implement interactive learning activities under the guidance of teachers.
After class time	• Grade, correct, and compile statistics on students' learning results. • Reward active students and remind others who may need improvement.	• Perform exercises to be graded automatically using the Code Runner tool. • Monitor the reports. • Self-assess their learning process.

The following passage describes the process detailed in Table I:

With ICT

Stage 1: Before class time

– Teacher's activities

- Select appropriate content for blended teaching. The content suitable for this learning model includes practical lessons in topics A, B, and C; articles in topic E; or articles in topic Applied Informatics.
- Determine the necessary learning materials based on the lesson objectives. Learning materials can include lecture slides, video tutorials, exercises, multiple-choice questions, and reference resources on the internet.
- Upload prepared learning materials to the learning management system (LMS).
- Assign tasks for students to complete.

– Students' activities

- Identify the goals to be achieved and specific learning tasks assigned by the teacher.
- Self-study the content of the lesson, complete exercises and multiple-choice questions based on the materials posted by the teacher and record any unclear concepts or questions for discussion with the teacher.
- Conduct self-study at home and at any convenient time. This contributes significantly to improving students' SDL skills.

Stage 2: During class time

–Teacher's activities

- Check students' performance of tasks at home. For example, assign students to perform an exercise individually or in pairs to explore the features of the internet after they have watched a video showing how to work at home.
- Organize activities for students to exchange ideas, discuss, and address their concerns.
- Review lesson content and assign homework.

–Students' activities

- Implement interactive learning activities under the guidance of teachers such as answering questions, discussing groups, and presenting ideas.

Stage 3: After class time

–Teacher's activities

- Grade, correct, and create statistics of students' learning results to adjust the process of building learning materials and learning activities to be more appropriate and effective.
- Communicate with unresolved questions during class time, reward active students and remind unresolved students through LMS.

–Students' activities

- Consolidate knowledge and practice more by expanding on the reference resources provided by the teacher.
- Monitor reports and evaluate learning outcomes to draw experiences and find the most suitable learning methods.
- Engage in self-assessment of learning processes and outcomes after school.

The following passage describes the process detailed in Table II:

With CS:

Stage 1: Before class time

–Teacher's activities

- Based on the lesson objectives, create learning materials including lecture slides, programming exercises, test cases for automatic code grading, multiple choice questions, and internet reference resources.
- Upload the prepared learning materials to the learning management system (LMS).
- Assign tasks for students to complete.
- Provide a self-study guide to each student upon logging into the LMS.

–Students' activities

- Identify the goals to be achieved and specific learning tasks from the assignments given by the teacher.
- Preview the lesson content and exercises based on the materials provided by the teacher.

Stage 2: During class time

–Teacher' s activities

- Use active teaching methods to guide students' learning, such as programmatic teaching, problem-solving, and discovery teaching.
- Organize exchange activities for students to discuss and answer questions they may still have after studying the lecture slides on their own, and record and mark their answers.
- Review the lesson content and assign homework.

–Students' activities

- Implement interactive learning activities under the guidance of the teacher, such as answering questions, group discussions and presenting ideas.

- Ask questions or raise issues from pre-class notes and bookmarks.

Stage 3: After class time

–Teacher's activities

- Grade, correct, and compile statistics on students' learning results to adjust the process of building learning materials and learning activities for greater appropriateness and effectiveness.
- Address unresolved questions during class time, reward active students, and remind unresolved students through the LMS.

–Students' activities

- Complete exercises to be automatically graded using the Code Runner tool on the LMS.
- Monitor the reports, evaluate the learning results to gain experience, and find the most suitable learning methods.
- Self-assess their learning process and outcomes after class.

B. Participants

The study participants consisted of 90 students from two classes, 10A11 and 10A12, at HoaiDucB High School in Hanoi. The study was conducted during the first semester of the academic year 2022–2023. The experimental class consisted of 45 students from class 10A11, and the control class consisted of 45 students from class 10A12. The two selected classes were equivalent in terms of learning level and were tested using the t-test based on the input assessment results of each student, as shown in Tables III, IV, and V.

TABLE IIII: CHECKING INPUT BASED ON STUDENT QUESTIONNAIRES

Group type	N	Average score for student self-assessment		
		Mean	SD	p
Control	45	3.17	0.07	0.312
Experiment	45	3.27	0.07	

TABLE IV: CHECKING INPUT BASED ON TEACHER QUESTIONNAIRES

Group type	N	Average SDL score as assessed by the teacher		
		Mean	SD	p
Control	45	1.58	0.07	0.5905
Experiment	45	1.64	0.06	

TABLE IV: CHECKING INPUT BASED ON THE TEST SCORE AT THE BEGINNING OF THE TERM

Group type	N	Average score		
		Mean	SD	p
Control	45	7.50	0.1	0.1986
Experiment	45	7.71	0.1	

With a p-value greater than 0.05, the difference in mean self-study scores between the two classes was not statistically significant. In other words, the SDL scores of the two classes were similar before the experiment.

C. The Blended Course

For experimental purposes, the Informatics 10 course was designed to include blended learning. The course provides students with video tutorials, multiple choice questions, and exercises for automated coding practice. The course is delivered asynchronously through a Learning Management System (LMS) located at http://tuhoctinhoc.live. This system is built on the Moodle platform and includes course descriptions, learning resources, announcements, and discussion forums. The experiment runs for a duration of 3 months and students are guided to study both on the system and in the classroom.

Teachers create learning materials and deliver the course using a combination of the following teaching methods:

Step 1: Selecting a lesson.

Suitable lessons for this model include exercises such as practicing the use of digital devices and computer network applications, as well as lessons in applied informatics and computer-aided problem solving.

These lessons have in common the fact that textbook instructions are presented through text and images, and teachers need to provide demonstrations and examples for students. Therefore, creating videos for these lessons can enhance the effectiveness of students' self-directed learning.

Step 2: Designing a lesson according to the model of blended learning.

Before class time: teachers need to create learning materials and upload them into the LMS. These materials should include lecture slides (if any), instructional videos for practical operations, multiple choice questions, exercises, input/output sets, and code for programming exercises.

The following are some suggestions to help teachers create appropriate learning materials for Informatics:

1) For the instructional videos, teachers can use screen video recording tools such as Camtasia, Screen Recorder, Free Cam, etc. When recording the video, teachers need to note the following points to guide students effectively:

- Start with a description of the process, general principles to be followed (For example, the process of using Google's Automatic Translation service consists of several steps) or a description of the product to be achieved (for a practical lesson). general practice), followed by detailed step-by-step instructions.
- Symbols should be used to emphasize difficult content or important information, such as circles, annotation tags, and arrows. For process instructions, it is recommended to clarify each step that students need to follow and to repeat it if necessary. These steps will be used to create activities that test students' performance in completing tasks.
- There should be a few questions in the middle of the video to check the students' understanding of the content. Camtasia allows you to do this very easily.
- Speak clearly, at a moderate speed, at a volume suitable for students to follow.
- The length of a video should not be too long; about 5–7 minutes is moderate and should not be longer than 10 minutes. A video that is too long will make it easy for

students to lose concentration and develop the urge to cheat while watching the video (fast forward).

- There should be tasks related to watching videos as soon as students complete them.

2) When creating multiple-choice questions, teachers should use a variety of question types that are suitable for the practical characteristics of the Informatics subject, such as questions about the ordering of processes, questions about recognizing the visual interface of command buttons and work screens, and so on. Moodle or I-Spring test tools provide a wide variety of question types with a friendly and easy-to-use interface.

3) With exercises for automatic code grading, teachers should carefully describe the input and output requirements for students to follow. Test cases need to be diverse enough to cover all cases of the problem.

During class time: Teachers should use teaching methods or active teaching techniques to create learning tasks that require students to practice and apply the knowledge they have learned on the LMS.

After class time: Teachers should review students' work, answer any questions on the LMS, and assign students to reflect and submit their results on the LMS.

Step 3: Implementing teaching according to the blended teaching model proposed above.

D. Data Collection and Analysis

For each student, there will be three ways to assess SDL competency:

- Students will self-assess their learning ability through a survey that includes 33 questions divided into five groups corresponding to five manifestations of SDL.
- Teachers will assess students' SDL competency through a teacher's survey consisting of 18 questions divided into five groups corresponding to five manifestations of SDL.
- The test score is the score obtained at the beginning and at the end of the Informatics subject of each class, which reflects the cognitive ability of the students.

To accurately assess the effectiveness of improving students' SDL competency between the two groups after the experiment (experimental group and control group), we will use the T-test method. The t-test is used to determine whether the mean of one group is statistically larger or smaller than the other group. The hypothesis is established as follows:

- $H_0 = \mu 1 < \mu 2$ (null hypothesis)
- $H1 = \mu 1 > \mu 2$ (alternative hypothesis)

Here, μ1 represents the mean value of the group of students participating in the experimental program (experimental group) and μ2 is the mean value of the group of students enrolled in the traditional program (control group). With 95% confidence, the null hypothesis (or mean score of experimental group has no difference with control group) is accepted when the p-value is greater than 0.05 and rejected when the p-value is less than or equal to 0.05.

III. Results and Discussion

After the experimental teaching process, we used the t-test to compare the degree of change in students' SDL between the two classes. The average output scores of the two classes were used for this comparison. The results are shown in Tables VI, VII, and VIII below.

TABLE VI: Checking Output Based on Student Questionnaires

Group type	N	Average score for student self-assessment		
		Mean	SD	p
Control	45	3.26	0.07	0.0163
Experiment	45	3.47	0.06	

TABLE VII: Checking Output Based on Teacher Questionnaires

Group type	N	Average SDL score as assessed by the teacher		
		Mean	SD	p
Control	45	1.80	0.05	0.0169
Experiment	45	2.04	0.08	

TABLE VIII: Checking Output Based on the Test Score at the Ending of the Term

Group type	N	Average score		
		Mean	SD	p
Control	45	7.73	0.1	0.0015
Experiment	45	8.32	0.1	

The results show that all three assessment methods provide consistent and positive results: the experimental class has a higher score than the control class after the teaching process. The difference was statistically significant with $p < 0.05$.

To evaluate the degree of change in each class, we divided the score range into four levels: 1, 2, 3 and 4. The distribution of scores for each class before and after the experiment is shown in the charts below (Figs. 1, 2, 3):

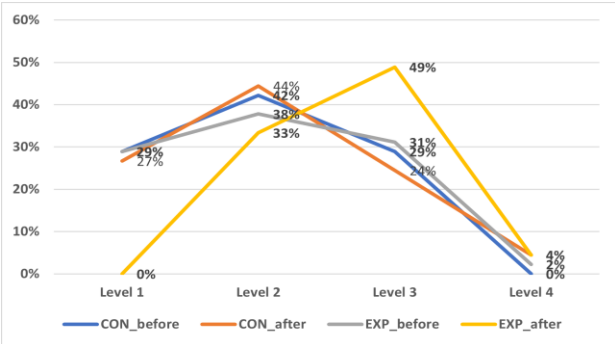

Fig. 1. The average score is self-assessed by students.

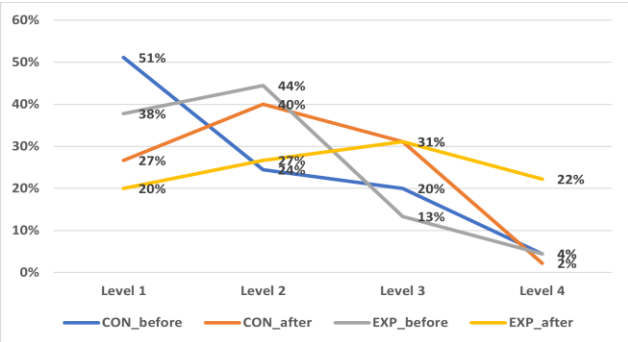

Fig. 2. The average score is assessed by the teacher.

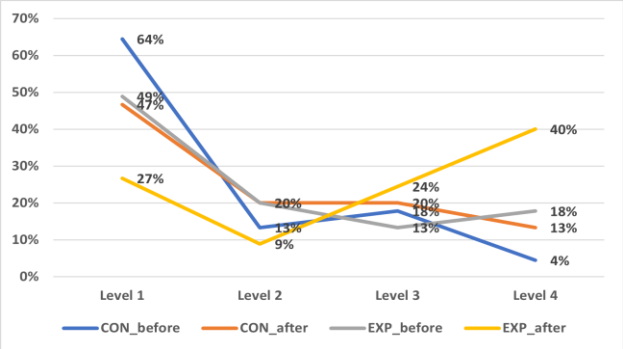

Fig. 3. The average test scores.

To test the difference between the two classes after the survey, we use the t-test. The test results for each assessment method of each class are summarized in the following tables (Tables IX, X, XI).

TABLE IX: SCORES OF STUDENTS' SELF-ASSESSMENT BEFORE AND AFTER THE EXPERIMENT

Group type	N	Average score for student self-assessment		
		Mean	SD	p
Experiment before	45	3.27	0.07	0.0247
Experiment after	45	3.47	0.06	
Control before	45	3.17	0.07	0.3569
Control after	45	3.26	0.07	

TABLE X: TEACHER'S SCORE BEFORE AND AFTER THE EXPERIMENT

Group type	N	Average SDL score as assessed by the teacher		
		Mean	SD	p
Experiment before	45	1.64	0.06	0.0002
Experiment after	45	2.04	0.08	
Control before	45	1.58	0.07	0.0171
Control after	45	1.80	0.05	

TABLE VIIII: TEST SCORES BEFORE AND AFTER THE EXPERIMENT

Group type	N	Average score		
		Mean	SD	p
Experiment before	45	7.71	0.1	0.002
Experiment after	45	8.32	0.1	
Control before	45	7.50	0.1	0.1307
Control after	45	7.73	0.1	

Looking at the test results as well as the graph, we can see that there is a difference between the mean scores before and after the experiment of each class. In all three ways of assessment, the experimental class had a higher mean score after the experiment (Experiment after) in the good and excellent levels. The difference is statistically significant with $p < 0.05$, which indicates that the experimental teaching approach effectively improved students' SDL competency.

Post-experimental assessment: The results of the post-teaching survey of the experimental class showed that 100% of students felt that their knowledge of computer science had expanded and 92% had increased their interest and love for computer science. Most of the students agreed that the learning method had a positive impact on themselves, such as expanding their knowledge of the Informatics subject, gaining knowledge associated with practice, enhancing their interest in the subject, and learning at their own pace and level (Fig. 4).

This survey aims to quantitatively determine the views of students about blended learning and its influence on SDL competency. The results from this survey and the scores of students obtained include the following statements:

1) The blended learning strategy can expand knowledge of Informatics.
2) The blended learning strategy can enhance computer skills.
3) The blended learning strategy can increase interest in learning Informatics.
4) Students can learn by their own pace and level through blended learning.
5) Students can learn anywhere and anytime through blended learning.
6) Students are more motivated to learn.
7) Students know how to identify learning goals and tasks, plan, develop and implement a reasonable learning strategy and self-assess their learning.

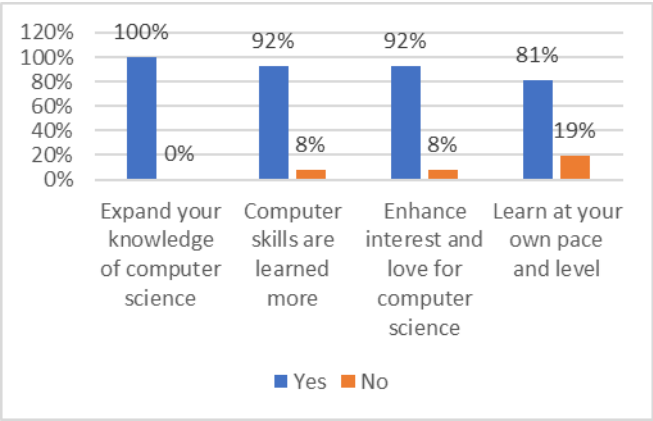

Fig. 4. Student survey results after the experiment.

This research represents a preliminary investigation into the learning outcomes and activities of students who participated in blended learning compared to those who participated in traditional face-to-face learning. The findings indicate that students who attended the blended learning approach demonstrated higher learning outcomes and a higher level of SDL than those who attended the traditional approach. These results are consistent with other studies in the literature which have demonstrated that blended learning can enhance student outcomes [31] and SDL [32, 33]. These findings encourage high schools in Vietnam to adopt blended learning approaches in their courses, particularly in the subject of Informatics, to promote learning environments that are more effective.

IV. CONCLUSION

The study has demonstrated that blended learning strategy, which combines classroom instruction and online learning, is an effective approach to develop SDL competencies in Informatics among high school students in Vietnam. The

research has provided convincing evidence that the proposed blended teaching process, which includes before, during, and after class phases, can lead to improved learning outcomes and higher levels of SDL competency. Specifically, the experimental group, which received blended teaching, exhibited significantly better results than the control group, which followed traditional teaching methods. Furthermore, students taught with the blended method expressed higher levels of satisfaction and engagement in their studies. As a result, we strongly recommend that high schools consider adopting blended teaching for other subjects as a means of modernizing their classrooms and enhancing the quality of education they provide.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Kieu Phuong Thuy conducted the research, analyzed data, and wrote the manuscript, while Nguyen Chi Trung provided feedback and made revisions. All authors had approved the final version.

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