The Influence of Distance Learning Contracted Live Teaching Strategies on Learning Effectiveness, Learning Motivation, Self-efficacy, and Cognitive Load

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Abstract

Distance learning lacks person-to-person interaction, which makes learning less interesting. While peer interaction can gain the support, assistance, and discussion of peer empathy, which can effectively motivate learning. This study proposes a remote peer live learning strategy, which allows learners to conduct peer learning anytime and anywhere via the Internet and uses peer-to-peer video methods to conduct peer-to-peer live teaching. Explores the influence of adding peer factors on their learning effectiveness and learning motivation. The findings of this study are as follows: (1) The learners who use peer live teaching strategy, regardless of whether they are high or low achievement, can effectively improve their learning effectiveness, learning motivation and reduce their cognition compared with those who use general distance teaching. (2) Students who utilized the peer-to-peer live teaching platform exhibited notably higher levels of technology acceptance compared to their counterparts enrolled in the conventional distance learning system.

Keywords: Peer live learning, Student-generated questions strategy, Peer feedback

1 Introduction

With the swift evolution of technology, remote learning is emerging as a novel educational trend, enabling students to acquire knowledge online at their convenience, free from the limitations of physical location and temporal constraints. Additionally, it empowers them to tailor their study schedules according to their individual learning needs [1]. However, historically, most forms of remote learning were hindered by technological limitations, leading to predominantly asynchronous communication and thereby restricting the expression of students' viewpoints. Therefore, it is important for distance learning systems to have a synchronous environment that can interact in real time, just like face-to-face [2].

In recent years, the frequency of people's daily use of live streaming has gradually increased, and the content of live streaming has also diversified. Live streaming has diverse and comprehensive communication channels, especially high-frequency interaction [3]. Therefore, how to apply modern contractual factors of live streaming technology to distance learning is the main research issue of this study.

Peer-to-peer learning has been widely recognized for its effectiveness in promoting active participation and knowledge construction among students. Student-generated questions strategy encourages students to think critically, reflect on their understanding, and foster creativity [4-6]. Similarly, peer feedback fosters higher-level thinking and enhances students' social and communication skills [7-8]. By incorporating these strategies into our study, we aim to leverage the benefits of peer interaction to enhance learning effectiveness and motivation in distance learning.

Peer live teaching is a new teaching strategy that not only brings the distance between the tutor and the tutee closer and increases the interaction and discussion between them, but also compares the tutor to the live streamer, so that the tutor can convey to peers more of the real picture of the main points of the course from the students' learning perspective and experience, and increase the connection between the peers, which is unmatched by traditional. Peer-to-peer distance learning is incomparable to traditional distance learning using teacher course videos. In addition, live streaming is the best way for the tutor to interact with the tutee because of the limited time of immediacy, allowing the tutee to give the best opportunity to clarify their concepts.

However, in order to help tutor to organize and clarify their understanding and reconstruct their knowledge, this study includes the learning strategy is student-generated questions strategy. In the past, students' learning achievement was often assessed by the teacher's question bank, but if student-generated questions strategy becomes a learning method for students, it would be a deeper conceptual reflection for them and cultivate their creative and innovative thinking. In this study, we added a learning strategy of student to generated questions, in which the system uses the what-if [9] problem generated framework to guide tutors in how to generate them to ensure their quality. Tutees can clarify their blind spots by answering the problems generated by them and allowing tutor to clarify the concept of knowledge he or

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she has learned through the questions.

Peer feedback promotes students' high-level thinking. In this study, we designed questions for live learning performance to allow students to give peer feedback, so that tutors can reflect on whether their teaching contents have improved tutees' learning effectiveness, and tutors can reflect on their own learning status to promote teaching and learning.

In order to teach the tutee and give them questions to answer before the live teaching, the tutor will prep the course and prepare the teaching materials to be shared life, also take more notes in the course handout to become the script for the live teaching activity. Peer live teaching is a one-to-one method in which students with better learning abilities teach those with weaker learning abilities. Live teaching can increase real-time interaction between peers, replacing the relationship of not daring to ask questions and discuss with the teacher face-to-face. At the end of the live teaching, the tutee examined whether they had listened carefully and improved their learning effectiveness by answering the questions asked by the tutor and then reflected on the feedback given by both sides to correct the deficiencies.

Based on the background and motives of the study, the questions of the study were as follows:

1) Can the peer live teaching strategy improve the learning outcomes of high achievement students in distance learning?

2) Can the peer live teaching strategy enhance the self-efficacy of high achievement students?

3) Can the peer live teaching strategy improve the learning outcomes of low achievement students in distance learning?

4) Can the peer live teaching strategy enhance the self-efficacy of low achievement students?

5) Can the peer live teaching strategy improve the learning motivation of students in distance learning?

6) Can the peer live teaching strategy reduce the cognitive load of students in distance learning?

2 Related Work

2.1 Distance Learning

Distance learning is seen as an educational methodology that transcends time and space and provides quality education that is constantly updated in the face of new technologies, while at the same time enabling them to be incorporated into the education and learning process [10].

The study results by Wen and Chang [11] showed that most students affirmed the effectiveness of distance learning and the implementation of distance learning course. In terms of teachers, their enthusiasm for teaching and curriculum preparation can affect their performance in synchronous distance teaching and the quality of post-class guidance, thereby influencing students' assessment of synchronous distance teaching outcomes [12-13]. As for students, Moore and Kearsley [14] have pointed out that the most important aspect to develop in distance teaching is to facilitate active learning by learners, and the most crucial factor affecting students' learning effectiveness is interaction. However, distance learning is different from traditional lecture teaching because students cannot participate in the actual classroom due to the nature and freedom of learning anywhere and anytime, which may cause students with poor reading habits to lag in learning. Therefore, before the implementation of distance learning, it must be carefully planned and designed, and the adaptability of learners and the possibility of using various multimedia must be considered to overcome the obstacles of separating the instructor and learners in two places and to achieve the desired learning effectiveness.

In addition, Derakhshandeh & Esmaeili [15] argues that the main purpose of online learning is to facilitate two-way interactive discussions between the instructor and the learners and active participation of the students. This study will investigate the use of peer encouragement and support in the process of multimedia distance learning to promote two-way interaction between teachers and students, which in turn enhances students' learning effectiveness and motivation. Therefore, this study adopts a peer mentorship method, in which peer groups of the same class are divided into two groups according to the level of ability, and students discuss and learn from each other through live teaching, so that the motivation and learning effectiveness of students with high and low achievement can be enhanced, and the effect of teaching and learning can be achieved.

Therefore, this study aims to develop a remote peer-to-peer live streaming teaching system for an algorithm course. This system enables peer instructors and peer learners to promote interaction and discussion through the platform, assisting students in absorbing course content and building knowledge. It facilitates peer learning and mutual exchange among students while further investigating their learning motivation and learning outcomes.

2.2 Peer Mentorship

Peer mentoring is one of the ways to implement peer learning and is a strategy that stems from the mentorship relationship. [8]. It allows students with higher learning ability or more learning experience and students with lower learning ability or less learning experience to learn in one-to-one pairs. Through the process of peer interaction, discussion, and assistance, the learning level of students with lower learning ability or less learning experience is enhanced.

The purpose of the peer mentorship in this study was to use peer influence to reach a level of language and experience that teachers could not reach. In addition, Ensher and Murphy argue that time and location are two of the main reasons for the failure of general apprenticeship, and suggest that teachers can use the Internet as a medium to help students learn without the constraints of time and location [16].

Gartner and Riessman [17] point out that in the peer mentorship learning strategy whether they are mentors or apprentices can learn the following in the learning process.

(1) The disciplinary knowledge, skills, and learning experiences of both mentors and apprentices.

(2) In a peer-to-peer mentoring learning strategy, the apprentice learner's experience with mentoring helps him/her to become a successful mentor in the future.

(3) Peer-to-peer listening and communication skills.

(4) Further understanding of the nature of "teaching" and "learning", especially the process of "learning" from "teaching".

In summary, the implementation of peer mentorship not only enhances learning attitudes and achievements, but also increases the self-confidence and social interaction between the students. Therefore, this study adopts a peer-apprenticeship approach to teaching and learning, in which students are divided into two groups according to their ability in the same class. Through the live peer teaching system, students are able to support each other, share learning experiences and discuss their work with each other, with the hope that through this learning strategy, the motivation and learning effectiveness of both high and low achievers can be enhanced, thus achieving the effect of teaching and learning together.

2.3 Peer Feedback

Peer feedback is beneficial to students in many ways, including increasing students' interest and motivation to learn [18-19], developing students' social, communication skills, and developing their critical evaluation skills [7-8]. Through peer feedback, students are encouraged to stimulate more creative ideas and inspiration and bring new thoughts to the table [20]. Peer feedback provides students with the opportunity to observe their peers' performance, learn from others' strengths and avoid the occurrence of the same weaknesses, and facilitate self-reflection [21]. Compare the differences between their expected and actual performance and make further corrections [22].

In this study, the questions were designed to focus on the live performance of tutors and tutees, and to allow them to give peer feedback after the live streaming, so that students could reflect on their own teaching content and live performance to promote teaching and learning and enhance each other.

2.4 Student-Generated Questions Strategy

Baumanns and Rott propose that problem solving is a personalized learning process in which students construct and create meaningful problems based on their own learning experiences [23]. Generating questions is a cognitive strategy and a postulated cognitive strategy. In the process of generating questions, students will focus on the key concepts of the textbook and deepen their understanding of the material. The students can also check whether they have really learned the content of the material. In the past, teachers always gave questions to students for examinations. This is a way to assess students' learning effectiveness over the years and a review method that teachers are used to using in order to understand each student's learning status and use it as a basis for improving teaching methods. If teachers can give students the opportunity to create questions at the right time, so that students can understand and analyze the problems through the process of creating questions and enter a higher level of thinking, it will not only help students to improve their problem-solving ability, but also promote the development of students' creativity, criticality and other higher level thinking ability [4-6].

In summary, student-generated questions strategy used by the tutors in this study before live teaching was the "what-if" strategy [9], which allowed students to substitute some of the elements of the question to form another question using the sample questions provided by the peer learning system. It is important to allow students to find their own self-worth, so that they can clarify their concepts, reflect on them, build up their self-confidence and enhance their self-concept in the process of generating questions.

Based on the above literature on multimedia distance learning, peer mentorship, peer feedback, and student-generated questions strategy, this study will build a multimedia audio-visual learning system for peer live learning, which has the live streaming function, questioning function, and peer feedback to explore the effects of adding peer factors to students' learning effectiveness and learning motivation during distance learning.

3 Research Method

3.1 Conceptual Framework

The study adopts different teaching strategies and learning achievement groupings to explore the differences in learning motivation, self-efficacy and cognitive load of algorithm courses, and to understand the influence of the participation of peers on their learning achievements. The research structure is shown in Figure 1. The independent variables are teaching strategies and learning achievements. The teaching strategies are divided into general multimedia distance learning and peer live learning; learning achievement variables are high achievement and low achievement; control variable are learner pre-knowledge and distance learning system; the dependent variable refers to the effect of learning algorithm effectiveness, learning motivation, self-efficacy and cognitive load after students complete learning activities through the learning system.

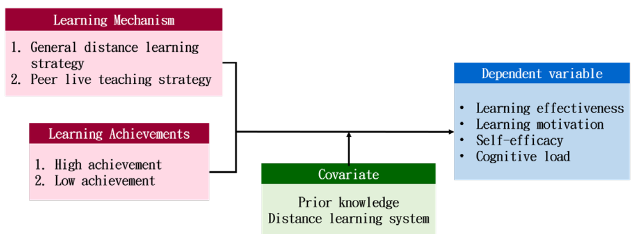

Figure 1. Conceptual framework

(1) Independent Variables:

The independent variables in this study are "teaching strategy" and "learning achievement." Regarding the "teaching strategy," the study explores the impact of peer-to-peer live teaching on learners in distance learning. The control group and experimental group are divided into those using a conventional distance teaching system and those using a peer-to-peer live teaching system, respectively.

Additionally, for the "learning achievement" aspect, student pairing is conducted based on the optimal grouping method proposed by Chen [17]. Students' pre-test scores are ranked from highest to lowest, and the number of students closest to the median value is assigned to the homogeneous group. The remaining students are assigned to the heterogeneous group, with the homogeneous group consisting of medium to high-achieving students paired with medium to low-achieving students, while the heterogeneous group consists of high-achieving students paired with low-achieving students.

(2) Dependent Variables:

The dependent variables in this study include post-test scores, learning motivation, self-efficacy, reflection ability, technology acceptance, and cognitive load. The learning effect, measured through students' performance on tests or assessments, allows us to evaluate the impact of the peer-to-peer live streaming teaching system on academic achievement and knowledge acquisition. Learning motivation, influencing students' engagement and persistence, determines their effort, interest, and enthusiasm for learning. By examining students' motivation levels, we can assess how the peer-to-peer learning environment facilitated by the system impacts intrinsic motivation, goal orientation, and interest in the subject matter. Self-efficacy, individuals' belief in their abilities, influences their willingness to take on challenges and exert effort. Investigating self-efficacy in the context of the system explores how it enhances confidence, belief in capabilities, and willingness to tackle challenges. Cognitive load, the mental effort required for processing information, impacts students' cognitive resources, mental workload, and learning efficiency. Examining cognitive load helps identify areas for system design and instructional strategy improvements to optimize the learning experience. After learners achieve their learning goals through the system, their final learning outcomes are reflected in the post-test. Independent samples t-tests are then used to explore the differences between the post-test scores of the experimental and control groups. Covariance analysis is employed to examine the pre-post differences in learners' motivation, reflection ability, and self-efficacy based on questionnaire results. Finally, independent samples t-tests are conducted to test the results of learners' technology acceptance and cognitive load after learning.

(3) Control Variables:

This study's participants are all guided by the same teacher, enhancing internal validity, and avoiding the influence of variables unrelated to the experiment. Furthermore, the study focuses on four units of the algorithm course: "The Greedy Approach," "Minimum Spanning Tree," "Prim's Algorithm," and "Kruskal's Algorithm." The learning materials and content for both groups in the distance learning course are identical, and efforts are made to ensure that students possess the same prerequisite knowledge.

3.2 System Interface

This study developed a remote peer-to-peer live streaming teaching system for an algorithm course, allowing instructors and learners to engage in online learning and participate in peer-to-peer live teaching activities. The study aimed to compare the differences in students' learning outcomes between the presence and absence of peers, the inclusion of question generation, and live teaching, as well as the differences between this approach and general remote learning methods. The user interface and workflow of the general remote teaching system (control group) are illustrated in Figure 2, while the user interface and workflow of the remote teaching combined with peer-to-peer live streaming system (experimental group peer learners) are depicted in Figure 3. The user interface and functionality explanation of the remote teaching combined with peer-to-peer live streaming system (experimental group peer instructors) will be detailed in Section 3.2.1.

3.2.1 System Interface

The learning system developed in this study combines remote teaching with peer-to-peer live streaming, question generation, and feedback functionalities. The system functions and interface for the experimental group (peer instructors) are introduced as follows:

1) Marking function: At the bottom of the course materials, there are two annotation tools: (a) a highlighter function for highlighting and (b) a function for adding text notes. Peer learners can freely draw key points on the textbook and take notes for future questions and live teaching sessions while watching the video provided by the tutor (Figure 4).

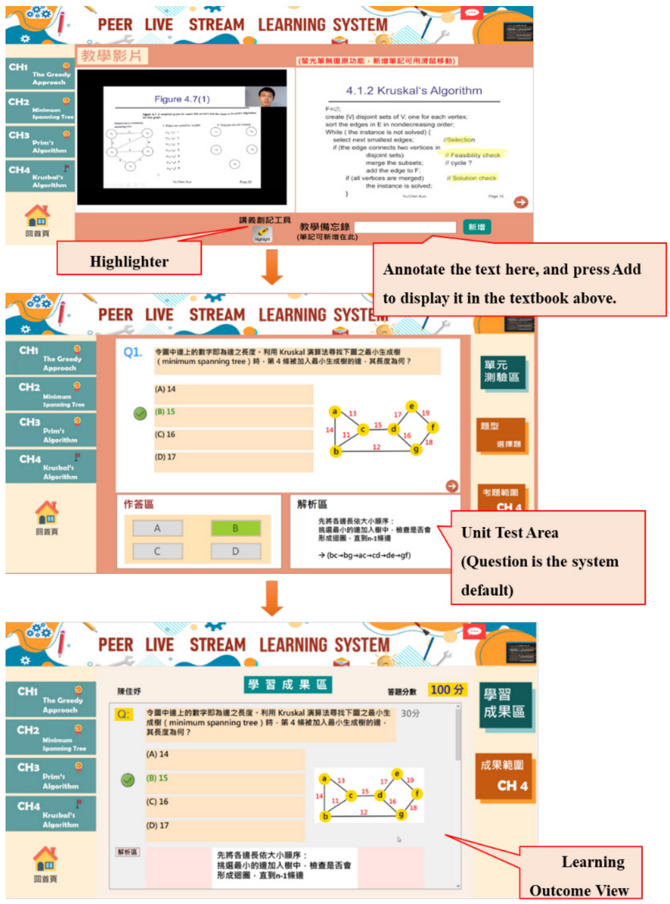

Figure 2. Illustration of the learning environment in the general remote teaching system (control group)

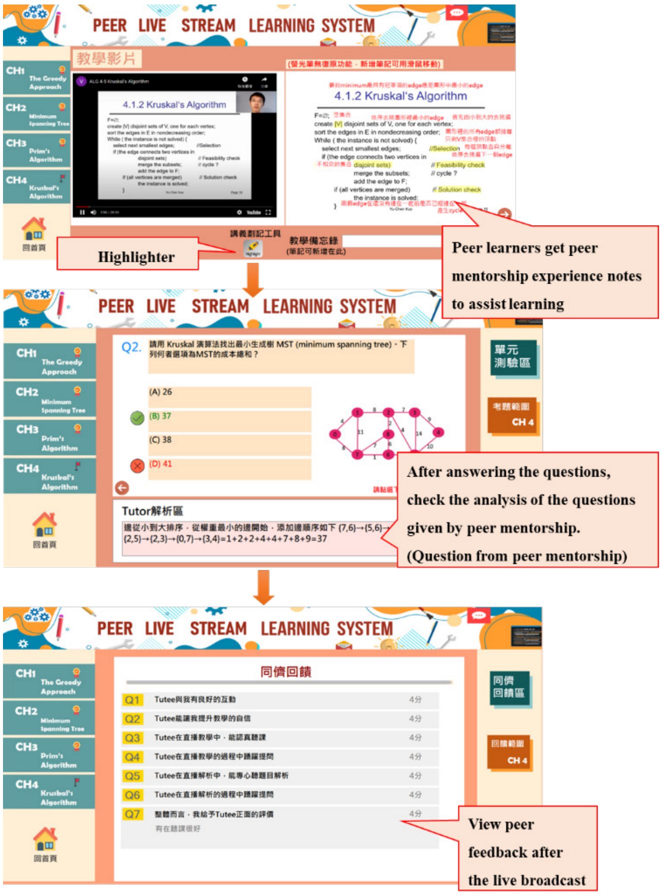

Figure 3. Illustration of the multimedia audiovisual learning environment in the remote peer-to-peer live streaming teaching system (experimental group peer learners)

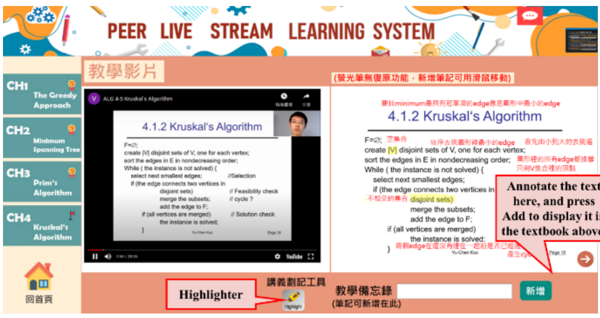

Figure 4. Marking function

2) Questioning-generated function: The system automatically reminds the tutor of the content of lesson notes in the lesson memo to help the tutor review each page of the lesson notes. The tutor's notes can be used as the basis for questions to check whether the key points of the tutor's notes have been correctly conveyed to the tutees. The tutor can choose to create questions on his or her own or be guided by the system when generating questions (Figure 5).

If the tutor chooses system-guided questioning, the system provides a total of 12 sample questions for all modules. This function will guide and assist tutors to use the what-if [4] framework for questioning (Figure 6).

3) Quiz function: After the peer live teaching, tutees must answer the questions given by the tutor. If tutee gets a question wrong, the tutor will explain the question for the tutee's answer, so that tutee can reflect on the answer (Figure 7).

4) Peer feedback function: After the peer live learning activity, the tutor and tutee can enter the peer feedback area to fill in the feedback form to rate the performance of both parties in the live teaching (Figure 8).

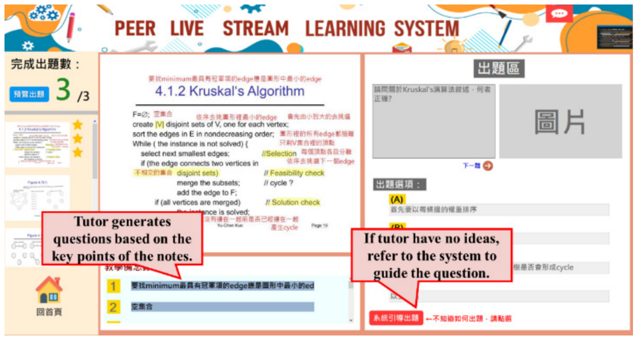

Figure 5. Questioning-generated function

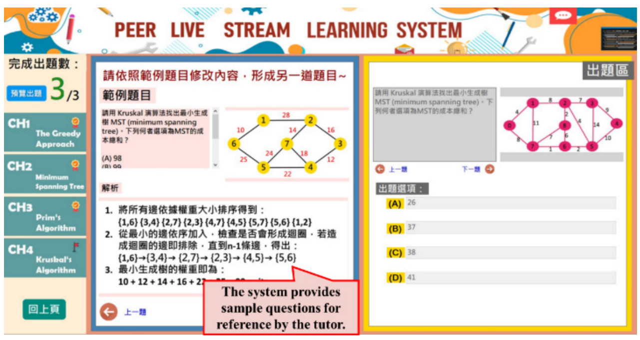

Figure 6. System-guided questioning function

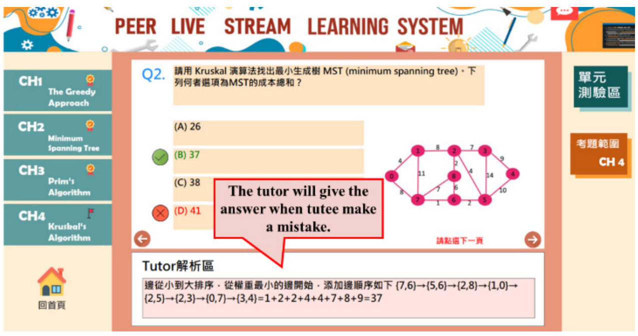

Figure 7. Quiz function

Figure 8. Peer feedback function

5) Review function: Tutor and tutee can check the status of their answers in this section (Figure 9).

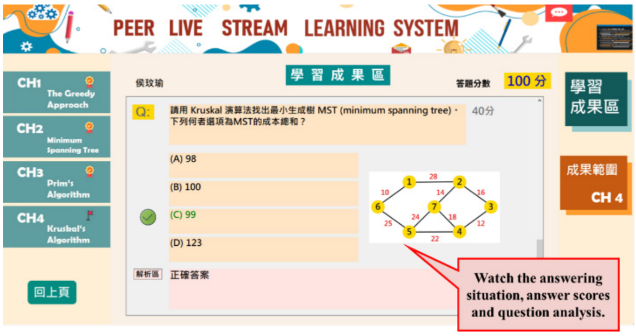

Figure 9. Review function

3.3 Experimental Design

This study developed a remote peer-to-peer live streaming teaching system for an algorithm course, allowing instructors and learners to engage in online learning and participate in peer-to-peer live teaching activities. The study aimed to compare the differences in students' learning outcomes between the presence and absence of peers, the inclusion of question generation, and live teaching, as well as the differences between this approach and general remote learning methods. The user interface and workflow of the general remote teaching system (control group) are illustrated in Figure 2, while the user interface and workflow of the remote teaching combined with peer-to-peer live streaming system (experimental group peer learners) are depicted in Figure 3. The user interface and functionality explanation of the remote teaching combined with peer-to-peer live streaming system (experimental group peer instructors) will be detailed in Section 3.2.1.

3.3.1 Experimental Participations

The participations of this experiment are the university students majored in computer science and information management, aged from 22 to 24, and total of 96 students. The experimental group of this study used the best grouping method proposed by Chen to conduct the pairwise grouping of students [17]. In order to match the experimental group size of 50 students, the number of equal ability group and mixed ability group could be the same, so the equal ability group was divided into 13 groups of 26 students, and the mixed ability group was divided into 12 groups of the remaining 24 students. The students in the group were paired in pairs in an S-shaped pairing, with the higher-achieving students serving as tutors and the lower-achieving students as tutees.

3.3.2 Learning Process

The study mainly investigated the effects of different teaching strategies (general multimedia distance learning, peer live teaching) and learning achievements (high achievement, low achievement) on the effectiveness of multimedia distance learning, and the flow plan of this experiment is shown in Figure 10. In order to verify the effectiveness of this study, a multimedia learning system with peer live teaching was developed to investigate the impact of peer teaching on distance multimedia learning. The experiment was designed using the algorithm course of the University Department of Information Management, and learners who had completed the data structure course were used as the subjects. Before the learning activity, the learners were asked to complete a pre-questionnaire, which included: motivation, self-efficacy, and then divided into experimental and control groups according to different teaching strategies. The experiment spanned four weeks, with one weekly study unit, each lasting 45 minutes. Prior to live teaching sessions, tutors were required to review the course materials and view pre-recorded video lectures provided by the learning system. This allowed tutors to share and engage in interactive discussions about their notes, enhancing their motivation and learning effectiveness through peer collaboration. Following their pre-study activities, tutors received questions related to the key points from their notes. When asking questions, the tutor can choose to ask questions on his or her own or ask the system to help guide the questions according to the what-if framework, and the questions will be based on his or her own notes to ensure that the key points of the notes are correctly transferred to the tutee. At the end of each module, learners will answer the questions asked by the live instructor in order to review the effectiveness of their learning during the live teaching. Finally, both sides entered the peer feedback area to give feedback on each other's performance in the live teaching, so that students could reflect on their own teaching content and performance in the live teaching, and promote mutual learning. At the end of the learning activity, each group took a 30-minute post-learning test and a post-questionnaire (motivation, self-efficacy, cognitive load).

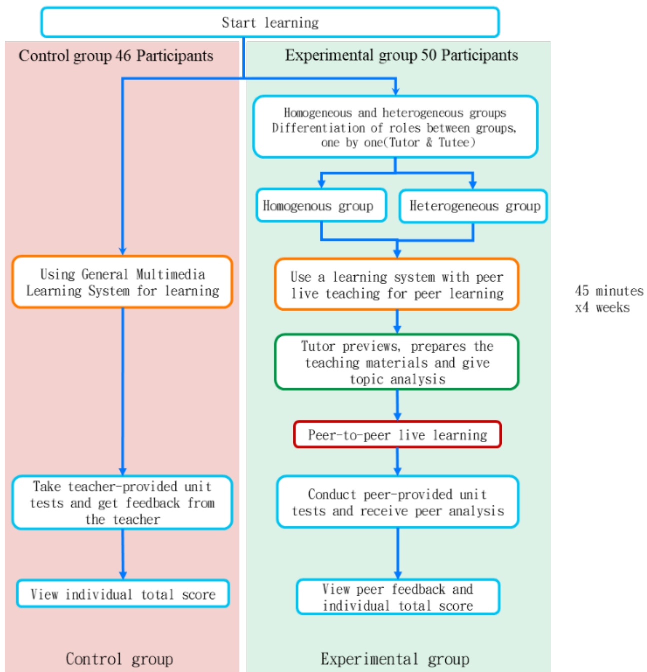

Figure 10. Experimental flowchart

4 Results

4.1 Students Learning Performance

In this section, we investigated whether there was a significant difference in the basic ability of algorithms between the experimental and control group students. In order to find out whether the experimental and control groups had the same level of prior knowledge of the algorithm, an independent sample t-test was conducted to analyze the difference in the prior knowledge of the algorithm between the two groups before the formal experimental activity. As shown in Table 1, the pre-test scores of the two groups did not reach a significant level of difference ($t=0.13$, $p=0.89>0.05$), indicating that there was no significant difference between the pre-experimental algorithmic abilities of the two groups, meaning that the students in the experimental and control groups had similar prior knowledge in the subject of algorithms.

Table 1. Pre-test of students between the experimental group and the control group

Group	N	Mean	SD	*t*
Experimental	50	77.06	12.04	0.13
Control	46	76.74	11.28	

In order to analyze whether there was a significant difference between the learning effectiveness of the experimental group and the control group, a post-learning test was administered after the learning activities, and the results of the test were analyzed by independent sample t-testing between the experimental group and the control group. As shown in Table 2, the learning effectiveness of the experimental group was significantly higher than that of the control group ($t=3.20$, $p=0.002<0.01$), which can be broadly inferred that the system can help the experimental group improve their learning effectiveness.

Table 2. Post-test of students between the experimental group and the control group

Group	N	Mean	SD	*t*
Experimental	50	86.40	17.21	3.20**
Control	46	72.33	24.83	

4.2 High achievement Learning Performance

In order to find out whether the knowledge of algorithmic prerequisites was the same between the high-achieving students in the experimental group and the control group, an independent sample t-test was conducted to analyze the difference in the knowledge of algorithmic prerequisites between the two groups before the experimental activity. The results of the analysis are shown in Table 3. The independent sample t-test analysis revealed no significant difference between the two groups ($t=0.57$, $p=0.57>0.05$), so it can be inferred that the high-achieving students had similar basic algorithmic skills before the experiment.

Table 3. Independent sample t validation of high achievement pre-test for the two groups

Group	N	Mean	SD	t
Experimental (high achievement)	25	78.76	12.87	0.57
Control (high achievement)	23	76.57	13.84	

At the end of the learning activities, the students were given a post-test to analyze whether there was a significant difference in the learning outcomes between the high achievement of the experimental group and the high achievement of the control group. The results of the post-test analysis are shown in Table 4. The learning outcomes of the high achievement in the experimental group were significantly higher than those of the high achievement in the control group ($t=2.62$, $p=0.013<0.05$).

Table 4. Independent sample t validation of high achievement post-test for the two groups

Group	N	Mean	SD	t
Experimental (high achievement)	25	88.80	15.74	2.62*
Control (high achievement)	23	72.61	25.57	

4.3 Low achievement Learning Performance

In order to find out whether the knowledge of algorithmic prerequisites was the same between the low-achieving students in the experimental group and the control group, an independent sample t-test was conducted to analyze the difference in the knowledge of algorithmic prerequisites between the two groups before the experimental activity. The results of the analysis are shown in Table 5. The independent sample t-test analysis revealed no significant difference between the two groups ($t=-0.54$, $p=0.59>0.05$).

Table 5. Independent sample t validation of low achievement pre-test for the two groups

Group	N	Mean	SD	*t*
Experimental (low achievement)	25	75.36	11.15	-0.54
Control (low achievement)	23	76.91	8.28	

The results of the post-test analysis are shown in Table 6. The learning outcomes of the low achievement in the experimental group were significantly higher than those of the low achievement in the control group ($t=2.12$, $p=0.04<0.05$).

Table 6. Independent sample t validation of low achievement post-test for the two groups

Group	N	Mean	SD	t
Experimental (low achievement)	25	84.00	18.57	2.12*
Control (low achievement)	23	70.96	23.89	

4.4 Comparing Self-Efficacy Among Learners in Two Groups

The self-efficacy questionnaire mainly discusses the self-efficacy for learning before and after learner activities. Using the Likert 5-point scale, the Cronbach's alpha of the pre and post questionnaires were 0.85 and 0.85.

The analysis of the pre-questionnaire for high achievement and low achievement self-efficacy was conducted using independent sample t-test analysis, and the results showed that there was no significant difference between the pre-experimental self-efficacy of high achievement in the experimental group and that of high achievement in the control group (t=0.46, p=0.65>0.05), and there was also no significant difference between the pre-experimental self-efficacy of low achievement in the experimental group and that of low achievement in the control group (t=-0.37, p= 0.71>0.05). The results of the analysis are shown in Table 7.

Table 7. Self-efficacy pre-questionnaire for learners in the experimental and control groups

Group	N	Mean	SD	t
Experimental (high achievement)	25	3.42	0.58	0.46
Control (high achievement)	23	3.34	0.67	
Experimental (low achievement)	25	3.26	0.65	-0.37
Control (low achievement)	23	3.32	0.35	

To analyze whether there was a significant difference in self-efficacy between the experimental and control groups of high and low achieving learners, a post-self-efficacy questionnaire was administered at the end of the learning activity and the post-self-efficacy questionnaire was analyzed as a covariate using analysis of covariance (ANCOVA). The results of the analysis showed that the self-efficacy of the high achievement in the experimental group was significantly higher than the high achievement in the control group (F=9.29, p=0.004<0.01), while the self-efficacy of the low achievement in the experimental group was not significantly different from the low achievement in the control group (F=0.16, p=0.70>0.05), as shown in Table 8.

Table 8. Self-efficacy post-questionnaire for learners in the experimental and control groups

Group	N	Mean	SD	F	η2
Experimental (high achievement)	25	3.98	0.67	9.29**	0.17
Control (high achievement)	23	3.40	0.62		
Experimental (low achievement)	25	3.74	0.63	0.16	0.003
Control (low achievement)	23	3.67	0.62		

4.5 Comparing Learning Motivation Among Learners in Two Groups

The motivation questionnaire mainly discusses the motivation for learning before and after learner activities. Using the Likert 5-point scale, the Cronbach's alpha of the pre and post questionnaires were 0.77 and 0.74.

The results of the analysis are shown in Table 9. The results of the analysis show that there was no significant difference between the learning motivation of the experimental and control groups before the experiment (t=-1.39, p=0.17>0.05), indicating that the learning motivation of the experimental and control groups before the learning activity was similar.

Table 9. Learning motivation pre-questionnaire for learners in the experimental and control groups

Group	N	Mean	SD	t
Experimental	50	3.63	0.55	-1.39
Control	46	3.79	0.60	

To analyze whether there were significant differences in the motivation of the experimental and control groups, a post-motivation questionnaire was administered at the end of the learning activity. The post-motivation questionnaire was analyzed using analysis of covariance by treating the pre-motivation questionnaire as a covariate and conducting an analysis of covariance (ANCOVA) on the post-motivation questionnaire. The results of the analysis are shown in Table 10. The mean of the post-questionnaires of the two groups showed that the post-questionnaires of the experimental group were significantly higher than those of the control group under the condition of controlling for the pre-questionnaires and reached a significant level (F=11.19, p=0.001<0.01).

Table 10. Learning motivation post-questionnaire for learners in the experimental and control groups

Group	N	Mean	SD	F	η2
Experimental	50	4.12	0.45	11.19**	0.11
Control	46	3.77	0.56		

4.6 Comparing Cognitive Load Among Learners in Two Groups

Cognitive load is divided into two aspects: mental load and mental effort. Using the Likert 7-point scale, the Cronbach's alpha of the questionnaires was 0.91. Mental effort is the extent to which the content of the learning materials used in the learning activity is a negative influence on the learner's learning. Using the Likert 7-point scale, the Cronbach's alpha of the questionnaires was 0.79.

The results of the cognitive load questionnaire were analyzed using independent sample t-tests. The results of the analysis are shown in Table 11, which showed that there was a significant difference between the experimental group in terms of mental load ($t=-2.50$, $p=0.014<0.05$) and mental effort ($t=-2.17$, $p=0.03<0.05$). The results of this analysis show that although the experimental group and the control group had the same teaching materials, the peer-to-peer live teaching strategy helped the experimental group students to understand the teaching materials more deeply, which in turn reduced their mental load and mental effort.

Table 11. Cognitive load independent sample t test results of experimental group and control group

Aspect	Group	N	Mean	SD	*t*
Mental load	Experimental	50	3.06	1.03	-2.50*
	Control	46	3.63	1.20	
Mental Effort	Experimental	50	2.86	1.17	-2.17*
	Control	46	3.40	1.28	

5 Discussion and Conclusion

This study aimed to develop an audiovisual learning system for peer-to-peer live teaching. The system integrated features such as live streaming, question generation, and peer feedback. The primary objective was to examine whether this system could enhance learners' motivation and effectiveness in their studies. Prior to conducting live teaching sessions, peer instructors invested additional effort in lesson preparation and formulating questions for their peers to answer. The live sessions were conducted in a one-on-one format, specifically targeting learners with weaker abilities to facilitate real-time interaction among peers. Following the lessons, the questions posed by the peer instructors were utilized to assess the attentiveness of the peer learners and enhance their learning effectiveness. The study adopted various teaching strategies and grouped learners according to their achievement levels to investigate the disparities in learning effectiveness, motivation, self-efficacy, reflection ability, cognitive load, and technology acceptance between the experimental and control groups in an algorithm course. The purpose was to gain insights into the impact of incorporating peers on the learning experience.

The use of remote peer-to-peer live teaching by peer instructors (high-achieving students) compared to general remote teaching by high-achieving learners contributes to enhancing their learning effectiveness, motivation, self-efficacy, reflection ability, and reducing their cognitive load and mental effort.

Based on the experimental results where students in the experimental and control groups had similar prior knowledge, it was found that the peer instructors in the experimental group achieved significantly higher scores in the learning effectiveness assessment after the experiment than the control group learners. This indicates that the peer-to-peer live teaching system developed in this study for algorithm learning has the benefit of improving learning effectiveness. These findings align with the research [24-25], which suggests that learners who take on the role of instructors in peer learning gain cognitive benefits comparable to learners. The preparation and guidance processes of peer instructors, through continuous integration and reflection, contribute to clarifying and consolidating concepts. Additionally, the performance of peer instructors in teaching mode surpasses that of individuals without teaching responsibilities. The questionnaire analysis revealed that in the context of the peer-to-peer live teaching system, peer instructors in the experimental group exhibited significantly higher levels of motivation, self-efficacy, and reflection ability after the learning activities. These results indicate that the use of the peer-to-peer live teaching system effectively enhances the learning motivation and self-efficacy of peer instructors, consistent with previous studies that have highlighted the positive correlation between higher levels of learning motivation and self-efficacy, as well as higher expectations and a strong desire to master the learning content [26- 27]. Moreover, significant differences were observed in terms of cognitive load, in line with the research by Daft and Lengel [28], which suggests that abundant information helps clarify ambiguous aspects and promotes understanding. Peer instructors not only obtain information provided by the teacher but also acquire knowledge from their peer learners. These findings demonstrate that the assistance provided through the peer-to-peer live teaching strategy helps peer instructors gain a deeper understanding of the instructional material, thereby reducing cognitive load and mental effort.

The use of remote peer-to-peer live teaching by peer learners (low-achieving students) compared to general remote teaching by low-achieving learners contributes to improving their learning effectiveness, motivation, and reducing their cognitive load and mental effort.

Based on the experimental results where students in the experimental and control groups had similar prior knowledge, it was found that the peer learners in the experimental group achieved significantly higher scores in the learning effectiveness assessment after the experiment than the control group learners. This corresponds to the research by Topping and Ehly [29], which suggests that although the quality of assistance and support provided by peer instructors may be inferior to that of teachers, the assistance provided is immediate and abundant, with different teaching approaches tailored to learners based on various environmental factors. Consequently, peer learning can effectively enhance learners' learning effectiveness. In the context of peer-to-peer live teaching activities, the peer learners in the experimental group exhibited significantly higher levels of motivation after the learning activities compared to before. These results indicate that the use of the peer-to-peer live teaching system effectively enhances the learning motivation of learners. It can be inferred that during live teaching sessions, learners have specific individuals to consult, and in a stress-free learning environment, their learning motivation can be effectively enhanced. Significant differences were also observed in terms of cognitive load, in line with the research by Daft and Lengel [28], which suggests that abundant information helps clarify ambiguous aspects and promotes understanding. Peer learners not only obtain information provided by teacher videos but also acquire knowledge from peer instructors. These findings demonstrate that the support provided through the peer-to-peer live teaching strategy helps peer learners gain a deeper understanding of the instructional material, thereby reducing cognitive load and mental effort.

The instructors and learners using remote peer-to-peer live teaching demonstrate significantly higher technology acceptance compared to the control group.

The analysis of the technology acceptance questionnaire revealed that the experimental group showed significantly higher acceptance of the peer-to-peer live teaching audiovisual learning system developed in this study compared to the control group. This indicates that the system functionality in the experimental group is helpful for learners during the learning process.

The subject of study in this research is the algorithm course, and it is recommended that the findings and methodologies can be applied to other subjects in the future. Furthermore, this paper employed a quantitative research approach to analyze learning outcomes based on experimental data, but it was unable to provide a deeper understanding of the changes in learning behaviors of instructors and learners during live streaming teaching. It is suggested that future studies incorporate more qualitative research methods to investigate the impact of peer-to-peer live teaching on student learning, allowing for a more comprehensive explanation of the research results. Additionally, the use of neuroimaging techniques, such as EEG, could be considered to assess students' attention or mind-wandering during peer-to-peer live teaching, enabling further analysis of its relationship with learning outcomes.

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