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Flipped classroom activities cooperated with graphic organizer technique to enhance grade 11 students' conceptual understanding of circular and lymphatic systems

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ABSTRACT

The purpose of the study was to examine the effectiveness of flipped classroom activities cooperated with graphic organizer technique as principles of a learning lesson plan to develop grade 11 students' conceptual understanding of circular and lymphatic system. The participants were 40 grade 11 students from a suburban school in northeastern Thailand, participants were sampled by cluster sampling. The instruments included a flipped classroom activities cooperated with graphic organizer technique a learning achievement test, and a conceptual understanding test. Data were analyzed using the effectiveness test and a rubric for conceptual understanding. The results indicated that the flipped classroom activities cooperated with graphic organizer technique effectively improved students' conceptual understanding of circular and lymphatic system, with most students demonstrating sound understanding of the concept. This study contributes to the field by proving that the flipped classroom activities is beneficial for older students, even within the thai educational context. it also confirmed that flipped classroom activities is particularly effective in teaching complex concepts in sceine education.

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1. INTRODUCTION

Biology has been a fundamental idea in science education since the early 19th century as it is a part of science education which serves as a gateway for students to comprehend the world (Rosenthal, 1990; Nurse, 2016). In a biology lesson, students are directed to understand the functioning of living creatures and their interactions with the environment, therefore; it also serves as a fundamental knowledge base for numerous job paths (Reiss, 2018; Wallis, 2012). For example, the concept of circulatory and lymphatic systems as a biology learning achievement is related to the understanding of how the human body maintains homeostasis, combats infections, and facilitates the appropriate delivery of nutrients. Understanding these concepts is not only essential for students

pursuing careers in healthcare and related fields, but also for fostering a deeper appreciation of biological processes. Therefore, it is beneficial to ensure that students are equipped with the knowledge they need to succeed in an ever-evolving scientific landscape.

Nevertheless, comprehending the concepts of the circulatory and lymphatic systems is challenging due to the numerous components involved. To be specific, understanding how the heart, blood vessels, lymph nodes, and lymphatic fluids interact to maintain bodily functions requires a deep integration of various biological principles (Seah, 2021). Moreover, the concept is also not familiar from students' daily lives, hindering their ability to connect classroom content to their experiences. This does not acknowledge their inherent complexity. To facilitate students' understanding of this context, educators must meticulously analyze what is required for learning such material.

At the late stage of their school education, grade 11 students are expected to be more autonomous, taking control of their learning and relying on their self-learning abilities to construct knowledge independently (Ferreira et al., 2019). According to Batanero & Sanchez (2005), at this stage of life, older high school students demonstrate a greater capacity for critical thinking, problem-solving, and synthesizing complex information. They are at a point where they can engage in more self-directed learning, which fosters a deeper understanding of the subject matter. This developmental phase suggests that grade 11 students should not only be encouraged to explore and discover but also to find personal motivation and interest in the material they study, creating a love for learning (Hammann, 2024). Therefore, teaching complex biological concepts such as the circulatory and lymphatic systems demands instructional methods that can support their growing independence by incorporating inquiry-based learning, hands-on experiments, and real-world connections that allow them to actively engage and apply what they learn.

In the context of Thailand, the concept of the circular and lymphatic systems is introduced at the grade 11 level, covering topics such as substance transport in organisms with open and closed circulatory systems, the heart, blood flow direction in humans, blood vessels, heart rate, blood types, blood transfusion, and the lymphatic system (The Ministry of Education, 2008). However, challenges arise when Thai high school students are found to struggle to retain and understand these interconnected topics due to their complexity. Implementing a flipped classroom model, combined with Graphic Organizer Technique, can significantly enhance learning (Ladachart & Ladachart, 2019). This can be addressed by giving students opportunities to engage with foundational content at their own pace before class, freeing up classroom time for active discussions and problem-solving activities that deepen comprehension. Moreover, it also a potential method to give an instruction that can also help students understand the relationships between the components, making it easier to grasp and remember the system's structure and functions.

The difficulty of the concept and the nature of high school students of grade 11 students' learning, the flipped classroom activities could be offered as a possible solution for the problem. According to Bergmann & Sams (2012), Flipped classroom activities could be defined as a pedagogical method whereby conventional lecture-based education is reversed. Under this approach, for example, students are exposed to fresh material at home via video lectures or readings while class time is set for more engaging, hands-on exercises and conversations that expand their knowledge (Flores-Alarcia et al., 2022). Students interact with instructional materials individually outside the classroom in a Flipped Classroom Activities; therefore, they may study at their own speed and review difficult topics as needed. Then, in-class, they put their knowledge to use via teacher-guided inquiry, group projects, and cooperative problem-solving (Reidsema et al., 2017). This method could encourage autonomy and active learning. It enables educators to focus on the areas where students require the greatest assistance, so rendering complex biological concepts more comprehensible and engaging (Al-Abdeli, 2017).

Moreover, graphic organizer technique can be beneficial in comprehending complex biological concepts as they can necessitate an understanding of several components and their relationships. A Graphic Organizer Technique is a visual instrument for clearly and systematically illustrating relationships between concepts to facilitate data organization (Gardill & Jitendra, 1999). Novak & Gowin (1984) claim that graphic organizer technique such as flow charts or idea maps. It helps students graphically show how various aspects of complicated systems are connected and break them down into more reasonable sections. In the current study, graphic organizer technique could allow students to organize the information in text or material. This comprehensive approach assists students in effectively constructing and organizing their knowledge, hence enhancing their comprehension of complex biological concepts.

Practically, the flipped classroom activities approach has proven to be an effective approach in biology education. Adonu et al. (2021) found that the use of flipped classroom activities strategies, alongside PowerPoint instructional approaches, significantly improved students' achievement and retention in biology. This suggests that providing students with opportunities to engage with content before class allows them to better grasp and retain complex biological concepts during interactive class activities. Similarly, Bozdağ et al. (2021) found that flipped classroom activities in biology teaching and observed a growing body of research supporting its effectiveness in enhancing student engagement and learning outcomes in biology education. Furthermore, Doğan et al. (2023) mixed research synthesis highlighted how the model offers students the ability to absorb theoretical concepts at their own pace and apply them in class through hands-on and inquiry-based learning activities. Kakarougkas & Abdellatif (2022) also observed that the flipped classroom activities approach, when combined with digital learning tools, significantly enhanced learning outcomes in an undergraduate molecular biology course, demonstrating that the model is well-suited for the complexities of biology education at various levels.

Likewise, graphic organizer technique have also be recognized to be effective in biology education. for empirical evidence, Schneeweiss & Gropengiesser (2021) introduced the Zoom Map to guide students' explanations across different levels of biological organization and found that it helped students structure their understanding of complex biological systems, making it easier to connect ideas across multiple levels of biological hierarchy. Similarly, Wallace et al. (2023) found that using inclusive writing-to-learn assignments with graphic organizer technique in large undergraduate biology courses significantly boosted student performance. These pieces of evidences support graphic organizer technique as tools that can provide a structured way for students to process and organize biological concepts, improving both their comprehension and retention of the material.

The current study aims to integrate the two principles in biology instruction to facilitate active and autonomous learning experiences for eleventh-grade students. Furthermore, prior studies advocated for the implementation of flipped classroom activities in advanced biology education, alongside the integration of additional teaching methodologies. This student aims to bridge the gap to achieve this objective. The proposes of the study was to examine the effectiveness of flipped classroom activities cooperated with graphic organizer technique as principles of a learning lesson plan to develop grade 11 students' conceptual understanding of circular and lymphatic systems.

2. METHOD

2.1 Research design

The study employed a one-group experimental design. A combination of the flipped classroom activities cooperated with graphic organizer technique served as the foundation for developing a learning lesson plan. The study's results were validated by evaluating the participants' learning outcomes regarding the circular and lymphatic systems during the execution of the learning lesson plan and subsequent to the intervention, demonstrating the strategy's effectiveness. The participants' comprehension of the concept was evaluated according to the standards established by Çoştu et al. (2012), which indicates that participants either fully or partially grasp the notion.

2.2 Participants

The participants were 40 grade 11 students in a province in northeastern Thailand. The school is in a suburban area, and the province ranked in the middle rank in both academic performances and socioeconomic status compared to the whole country. The participants were selected using a cluster sampling method using class as a criterion. They were treated considering ethical issues in human research.

2.3 Instruments

2.3.1 Flipped classroom activities cooperated with graphic organizer technique

The learning lesson plan was developed using the flipped classroom activities principle to facilitate learning of the circulatory and lymphatic systems. Therefore, the learning activity includes the stages of pre-class assignments – providing students video lectures and reading materials to introduce the fundamental concepts of the circulatory and lymphatic systems and in-class sessions - the use of interactive learning, including group discussions, hands-on experiments. The use of graphic organizer technique like mind map and concept maps, circle map, compare table map were used here to help students visualize the relationships between the components of both systems.

Additionally, students were asked to participate in problem-solving tasks and real-life case studies that encourage them to apply their knowledge, further deepening their understanding of these complex biological systems. The learning lesson plan included 9 lesson plans covering the topics of substance transport in organisms with an open circulatory system, substance transport in organisms with a closed circulatory system, heart, direction of blood flow in humans, blood vessels, heart rate, blood, blood groups and blood transfusion, and lymphatic system. Each lesson plan included the activity and assessment of its own. The evaluation of the lesson plan by 5 scholars in education and professional teachers indicates a very high level of appropriateness ranking from 4.70-4.86 for lesson plans.

2.3.2 Circular and lymphatic system test

The examination consisted of four multiple-choice questions. It comprises 30 elements pertaining to the subjects outlined in the learning lesson plan. All items demonstrated adequate content validity (IOC = 0.5-1.0), difficulty (p = 0.33-0.68), discrimination (b = 0.2-0.89), and reliability (r_{cc} = 0.89).

2.3.3 conceptual understanding test

The test consisted of 10 items, requiring students to select a choice and write a short paragraph explaining why their choice is correct. Their responses were evaluated using a rubric adapted from Çalık (2008) and Costu et al. (2012). Detailed information about the rubric can be found in Table 1.

Table 1 Rubric scoring for conceptual understanding test

Level of understanding	Criteria	Score
1. Sound Understanding (SU)	Students choose the correct answer and explain their reasoning with all key components fully and accurately aligned with widely accepted scientific concepts.	4
2. Partial Understanding (PU)	Students choose the correct answer and explain their reasoning correctly, but some key components are missing or incomplete.	3
3. Partial Understanding with a Specific Misconception (PU&SM)	Students choose the correct answer, and some parts of their explanation are accurate, but other parts include misconceptions not aligned with scientific concepts.	2
4. Specific Misconception (SM)	Students choose the correct answer, but their explanation is incorrect based on scientific concepts.	1
	Students choose the wrong answer, but parts of their explanation are correct.	
5. No Understanding (NU)	Students' answers reflect incorrect concepts, no response, responses such as "I don't know" or "I don't understand," or responses that do not address the question or simply repeat the question.	0

2.4 Data collection and data analysis

The data were collected during the 2nd semester of the 2023 academic year. The learning lesson plan was implemented to teach the concept of circular and lymphatic systems. In each lesson plan, the students' performances were assessed. Post-examination and conceptual understanding test took place after treatment. The data were analyzed using learning lesson plan effectiveness test which E1 is participants' performances in lesson plans per the full mark, and E2 is presented by the proportion of the participants' post-test score per full mark. Both quantities are compared to the criteria of 70/70. The participants' conceptual understanding was analyzed using the rubric.

3. RESULTS

The results of the study indicate the effectiveness of the learning lesson plan as the proportion of the participants' learning achievement of circular and lymphatic system during the implementation of plan was 87.34 % of the full mark. Meanwhile, the average score of the participants' post-test was 82.94 out of 100 maximum point accounting to 82.94% (Table 2).

Table 2 The effectiveness of flipped classroom cooperated with graphic organizer technique

Effectiveness	Maximum point	$\bar{x}$	S.D.	%
Effectiveness of the process (E_1)	100	87.34	2.77	87.34
Effectiveness of the product (E_2)	100	82.94	8.52	82.94
The Effectiveness of the learning management plan (E_1/E_2) = 87.34/82.94				

Therefore, the effectiveness of the flipped classroom activities cooperated with graphic organizer technique lesson plan was 87.34/82.94 reaching the predetermining criteria of 70/70 (Figure 1).

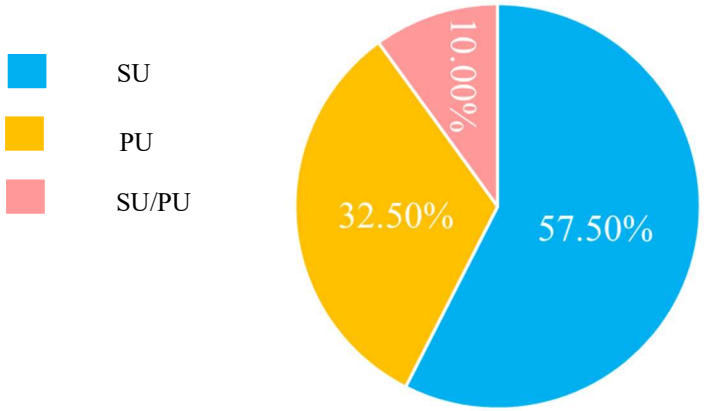

Figure 1 The conceptual understanding of the participants

Figure 1 indicates that the majority of the participants, 57.50%, demonstrated sound understanding (SU) of the concepts, while 32.50% exhibited partial understanding (PU). Additionally, 10.00% of the participants showed sound understanding / partial understanding (SU/PU) .This suggests that although more than half of the students have a strong grasp of the material, a significant portion still struggles with incomplete or incorrect understandings, highlighting areas that may need further instructional focus.

4. DISCUSSION

As the results show, integrating flipped classroom activities cooperated with graphic organizer technique can lead to positive outcomes in science education, particularly in biology classes. Specifically, the learning management plan can yield significant improvements in students' performance during and after activities, with most students achieving a true understanding of the concepts. Flipped classroom activities, in particular, contributes to this by allowing students to engage with content prior to class, freeing up in-class time for deeper discussions, hands-on activities, and critical thinking exercises (Bergmann & Sams, 2012; Reidsema et al., 2017). This model shifts the focus from passive reception of information to active application, making learning more student-centered and adaptable to individual needs. It helps students prepare for complex concepts by providing opportunities to revisit challenging materials, ask informed questions in class, and engage in collaborative problem-solving during face-to-face sessions (Al-Abdeli, 2017) .

Flipped classroom activities cooperated with graphic organizer technique by providing a structured way for students to process and organize the content they have studied at home. These tools visually map out relationships between concepts, making it easier for students to understand the connections between different parts of the material (Gardill & Jitendra, 1999; Novak & Gowin, 1984) . When used in a flipped classroom activities setting cooperated with graphic organizers technique help students integrate pre-class learning with in-class activities, allowing them to visually track their understanding and correct any misconceptions in real time. This combination of pre-class preparation and in-class application ensures that students not only grasp individual concepts but also understand how they fit into larger systems, making their learning more coherent and meaningful.

The findings went in line with previous investigations which also found the benefits of flipped classroom activities cooperated with graphic organizers technique on biology education (e.g., Adonu et al., 2021; Bozdağ et al., 2021; Doğan et al., 2023; Flores-Alarcia et al., 2022; Kakarougkas & Abdellatif, 2022; Schneeweiss &

Gropengiesser, 2021; Seah, 2021; Wallace et al., 2023). For example, while Adonu et al. (2021) observed that flipped classroom activities strategies, paired with PowerPoint instructional approaches, significantly improved students' achievement and retention in biology, the current study found that combining flipped classroom activities cooperated with graphic organizers technique not only improved achievement but also enhanced students' ability to connect complex biological concepts, such as the circulatory and lymphatic systems. Bozdağ et al. (2021) also noted a growing body of research supporting the Flipped Classroom Activities's the effectiveness in enhancing student engagement and learning outcomes in biology education.

Additionally, Kakarougkas and Abdellatif (2022) demonstrated how the flipped classroom activities, when integrated with digital learning tools, significantly improved learning outcomes in an undergraduate molecular biology course. In line with this, our study suggests that integrating graphic organizers technique as a tool within the flipped classroom activities further strengthens students' comprehension, allowing them to visually organize and synthesize biological knowledge effectively. This approach not only enhances retention but also encourages deeper engagement with the material, fostering critical thinking skills essential for success in the field of molecular biology. As students navigate complex concepts through visual representation, they become more adept at applying their knowledge in practical scenarios.

5. CONCLUSION

The objective of study was to determine the extent to which the flipped classroom activities cooperated with graphic organizers technique facilitate the comprehension of intricate biological concepts of circular and lymphatic systems, by grade 11 students. The findings of a one group experimental study indicated that students who engaged in flipped learning activities cooperated with graphic organizer technique demonstrated improved academic performance, increased interest, and a more comprehensive comprehension of the subject matter. The majority of students correctly identified the information, with only a small number demonstrating only partial comprehension or specific misunderstandings.

The results study add evidence to support flipped classroom activities as an effective method for older high school students in the Thai education context. This demonstrates that the flipped classroom activities when integrated into graphic organizer technique is effective when teaching complex concepts, such as those found in biology, which necessitate students to consider the connections between various ideas. Providing students with exposure to the subject matter prior to class and utilizing class time for interactive, hands-on activities, the reversed classroom facilitated their engagement and critical thinking.

For the implication of the study, educators should consider incorporating the flipped classroom activities cooperated with graphic organizer technique to facilitate student learning, particularly when students are studying challenging or ambiguous subjects. This study demonstrates that flipped classroom activities could be further investigated in a wider range of subject areas and education settings from an academic perspective. Additional research could be conducted in the future to determine the extent to which flipped classroom activities can be adapted to accommodate students' learning patterns and to facilitate the acquisition of knowledge in other scientific disciplines.

However, there were some limitations found in the design of the study. It could be noted that the results may not be generalizable to all circumstances due to the limited sample size. Additionally, qualitative data collection methods, such as student interviews or remarks, were not implemented in the study, which would have provided additional insights into students' perspectives regarding flipped classroom activities cooperated with graphic organizer technique and the. in order to obtain a more comprehensive understanding of the impact of Flipped Classroom Activities on student learning, additional research should be conducted in the future, utilizing qualitative methods and larger sample sizes.

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