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Enhancing Computer Science Education Through Electronic Team-Based Learning: A Hybrid Approach to Collaborative Learning

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Abstract *– This paper explores the implementation of electronic Team-Based Learning (e-TBL) as a hybrid educational solution, which combines traditional Team-Based Learning (TBL) methodologies with electronic platforms to enhance collaborative learning experiences. The study aims to assess the effectiveness of e-TBL in improving knowledge acquisition, teamwork skills, and overall academic performance among computer science students. The research was conducted in five comprehensive phases, including preparation, experimentation, and evaluation, with a particular focus on developing an e-learning application integrated with the Moodle platform. The findings of the study indicated significant improvements in student motivation, engagement, and academic achievement due to the implementation of e-TBL. Additionally, the study highlighted the increased interaction and collaboration among students, which contributed to a deeper understanding of the course material. The results support the conclusion that e-TBL is an effective educational strategy that can be integrated into various educational settings. It underscores its adaptability and potential for enhancing learning outcomes in both traditional classroom and online learning environments. The study concludes with several recommendations for educators and institutions on how to effectively integrate e-TBL to maximize its benefits, ultimately promoting a more interactive and engaging learning experience for students.*

Keywords: *Electronic Team-Based Learning (e-TBL), Collaborative Learning, e-Learning, Student Engagement, Academic Performance*

I. INTRODUCTION

Team-based learning (TBL) has emerged as a prominent instructional strategy in various educational settings, aiming to enhance collaborative learning and critical thinking skills among students (Fadelelmoula & Abdalla, 2022). TBL is a pedagogical approach that involves dividing students into teams to work on problem-solving activities, discussions, and assessments (Burgess et al., 2020). Over the past few decades, researchers have delved into understanding the dynamics of team learning, emphasizing the importance of time in shaping team interactions and outcomes (Wiese & Burke, 2019). The utilization of frameworks like the Input-Process-Output model has provided a structured way to analyze team learning behaviors and their impact on performance (Wiese et al., 2021). In the context of healthcare education, incorporating TBL as a prebriefing modality has shown promising results in improving communication, interaction, and preparedness among team members (Song, 2023). Interdisciplinary applications of TBL also have been explored, showcasing its effectiveness in integrating knowledge across diverse fields such as business, engineering, and design (Bailey et al., 2020). Studies have highlighted the benefits of TBL in undergraduate health science programs, indicating its potential to enhance traditional teaching methods and introduce active learning strategies (Sakamoto et al., 2020).

In the medical field, team-based learning has been linked to improved clinical reasoning and learning outcomes among nursing students (Drareni, 2019). The integration of TBL in courses related to cardiovascular diseases has demonstrated how this approach can facilitate interdisciplinary learning and problem-solving (Harvey

et al., 2019). The impact of team learning orientations, psychological safety, and open-mindedness on the effectiveness of TBL has been a subject of interest, revealing how these factors interact to influence team learning outcomes (Kerivel et al., 2021). Longitudinal studies have provided insights into the evolving nature of team learning processes and the importance of frameworks like the Inputs-Mediators-Outputs model in understanding team dynamics (Brykman & King, 2021). Research has explored the role of team resilience capacity and environmental factors in fostering effective team learning environments (Sinha & Stothard, 2020). Understanding power dynamics, egalitarianism, and environmental hardships can further enhance our comprehension of team learning mechanisms and outcomes (Orsini et al., 2021).

In educational contexts, TBL has been associated with improved student performance, grades, and overall learning experiences (Ahn & Lee, 2020). Studies have also investigated the impact of TBL on self-directed learning abilities, interpersonal understanding, and satisfaction among students, highlighting the benefits of collaborative and project-based learning approaches (Lewis & Estis, 2020). The effectiveness of TBL in enhancing mathematics content mastery, problem-solving skills, and flexible learning has been underscored in various studies (An, 2021).

The integration of TBL in online environments and gamified learning settings has shown promise in engaging students and promoting active participation.

This article explores the concept of electronic Team-Based Learning (e-TBL) and its impact on collaborative learning environments. Team-Based Learning (TBL) is a pedagogical approach that involves dividing students into teams to engage in problem-solving activities, discussions, and assessments, fostering critical thinking and teamwork skills Andrews-Dickert (2024). The integration of technology into TBL, known as e-TBL, combines the benefits of traditional TBL with electronic platforms to create a dynamic and interactive learning experience (Hashemikamangar & Gholampourdehaki, 2021).

II. METHODS

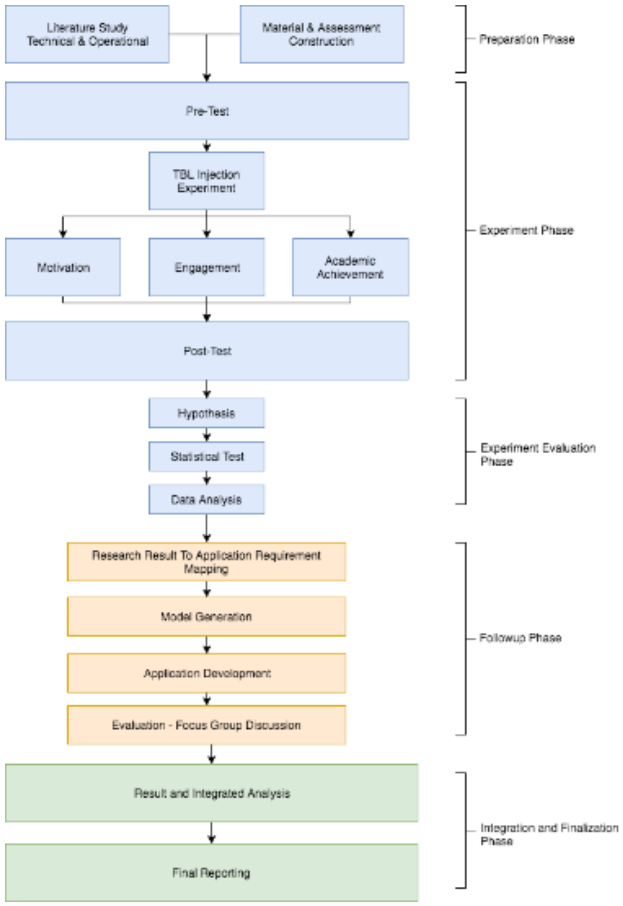

Figure 1. Research Methodology

There are 5 major phases in this research. The first 3 phases (Preparation Phase, Experiment Phase, and Experiment Evaluation Phase) are covered in previous publication (Makalew, 2017)

2.1 Preparation Phase

The preparation phase involved a comprehensive literature review covering both technical and operational aspects. The technical review focused on methodologies, execution methods for Team-Based Learning (TBL), and statistical analysis techniques. The operational review prepared the lecturer, who also served as the researcher, to deliver the course content effectively. Additionally, materials and assessments were constructed in parallel to ensure consistency and fairness between the experimental and control classes.

2.2 Experimental Phase

The core of the research employed a quantitative method with a pre-post test study design. The population consisted of approximately 6,000 Computer Science students at Bina Nusantara University, with a sample of one class expected to have over 50 students. The variables measured were motivation, engagement, and academic achievement, using the MSLQ, SEI, and a self-made test, respectively. The

2.3Experiment Evaluation Phase

In this phase, the collected data was evaluated to draw conclusions and inform decision-making. The process

included Hypothesis Creation, Statistical Testing, Data Analysis, and Reporting.

2.4 Follow-up Phase

This phase involved applying the research findings to develop a practical application. The steps included:

- Mapping Research Results to Application Requirements: The findings from the experiment were translated into requirements for the application.
- Model Generation: Based on the requirements, a model was created and depicted using Use Case and Conceptual Class Diagrams.
- Application Development: Utilizing Moodle, the application was developed in accordance with the model.
- Evaluation: An FGD (Focus Group Discussion) with five students from the class was conducted to evaluate the application. Feedback was gathered to refine and improve the application.

2.5 Integration and Finalization Phase

In the final phase, insights from both the experimental and application development phases were synthesized to form comprehensive conclusions. The process included:

- Analysis and Synthesis: Integrating findings from the research and application phases to draw meaningful conclusions.
- Report Preparation: The conclusions were documented in a detailed report.
- Submission for Publication: The final report was prepared for submission to a second international journal, ensuring that the research findings were disseminated to a wider academic audience.

III. RESULTS AND DISCUSSION

Based on the data collected on the Experiment Evaluation phase, the software model was depicted into use case diagram and conceptual class diagram. The mapping of TBL Core activities and the web application features are shown in Table I.

Table I. TBL Core to Feature Mapping

Supported TBL Core	Web Feature
Robust Team Learning	Internal & Collective Discussion Forum
Post-Classroom assessment / homework	Online Test with immediate feedback
Post-Classroom assessment / homework	Online Attendance
Pre-Classroom material / Readiness Assurance Process	Online Material
Problem Based Learning	Discussion Forum
Readiness Assurance Process	Clear Lesson Goal & Curriculum

Discussion forum is implemented to push the robust team learning. Students from the same group could participate in their own respective forum to communicate with their team about their tasks. In addition, the students are allowed to discuss other additional topics outside of the lesson, so that can improve team bonding. Collective discussion forum is used as a medium for the instructor to give problem to students, in which students must participate actively.

In the assessment part, students are given online test with immediate feedback. They are given answer and its explanation right after they finish the assessment. The assessment functioned as a replacement of homework in TBL. The teacher gathered the scores more easily, and is able to provide substantive and non-substantive feedback in the next classroom meeting collectively, per group, or per individual.

The instructor is also able to give online material for the students to study. To further increase the understanding of the material, students are asked to answer some questions in regards of the material.

All of the learning curriculum, both material and assessment are mapped and explained holistically in the curriculum and lesson goal section. All students are also asked to read the lesson plan and goals carefully. This is done so the students know what is the main purpose of the lesson. According to Chen et al. (2010), this is crucial in improving students' motivation in the subject.

The final features to develop are as follows:

1. Discussion forum for team,
2. Discussion forum for class,
3. Online test,
4. Online material sharing,
5. Curriculum placement.

3.1 Use Case Diagram

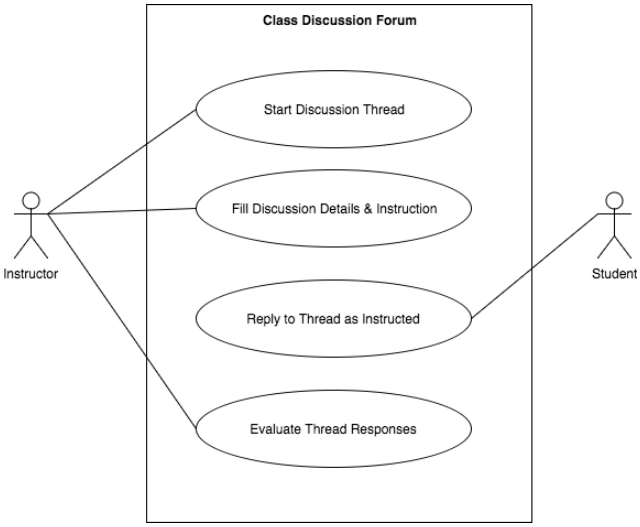

Figure 2. Use Case for Start Class Discussion Forum

In this use case, the instructor starts the discussion by making a thread in the forum. Afterwards, the instructor fills all discussion details and the instructions. Upon finishing the detail filling, the students are now able to reply to thread as instructed. Finally, the instructor evaluates the responded thread.

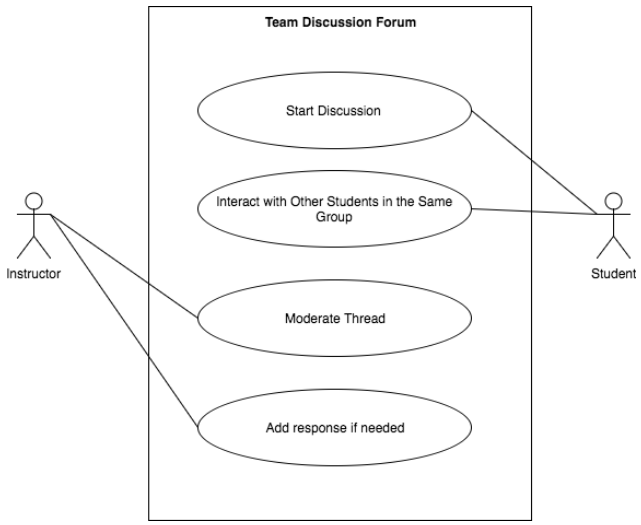

Figure 3. Use Case for Start Team Discussion Forum

In this use case, team leader or any member of the team starts the discussion by making a thread in the forum. Team members are able to engage in the discussion. The instructor monitors the discussion and deletes or adds replies according to needs.

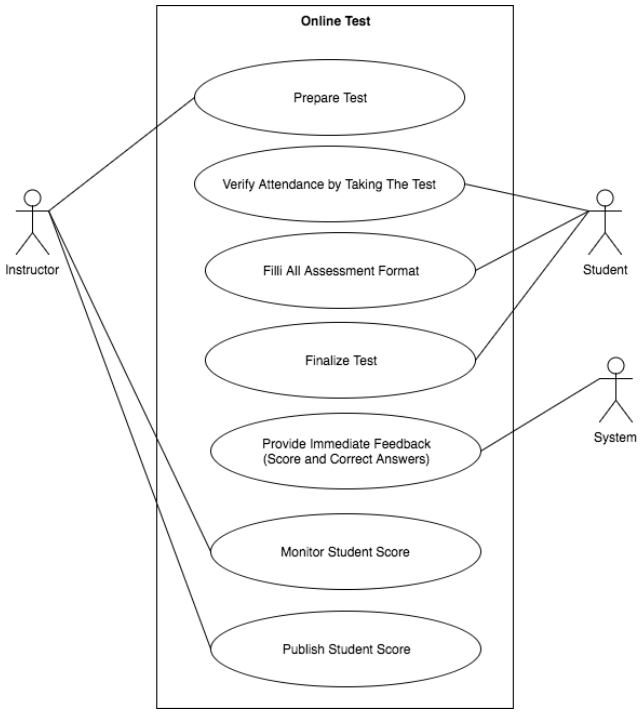

Figure 4. Use Case for Start Online Test

The instructor prepares the test by filling in the required questions and response field. After the assessment is created, the students start the assessment in conjunction with taking attendance for the test. After the test is finished, pre-defied immediate feedback is given to the students. Following that, the instructor monitors the students' score and publishes the scores online.

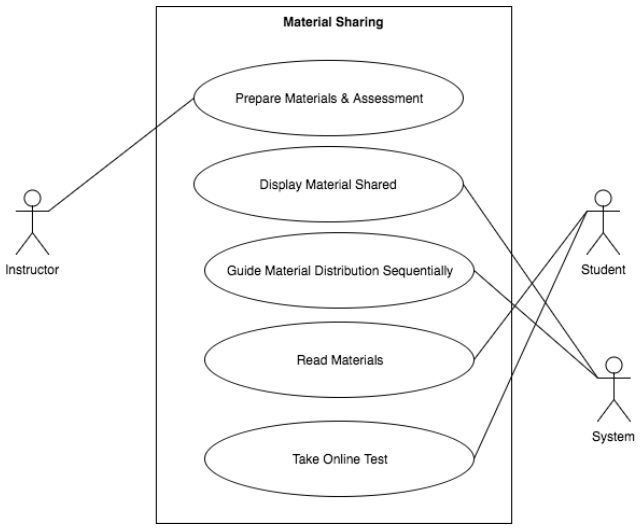

Figure 5. Use Case for Start Material Sharing

The instructor prepares the material by uploading it to the system. After the material is uploaded, the students start the material taking processaccording to the instruction. Following that, the students take another online test to further improve the understanding of shared material.

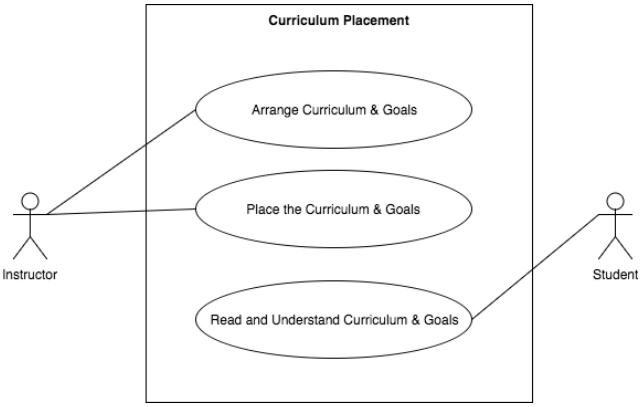

Figure 6. Use Case for Start Curriculum Placement

The instructor formulates the curriculum needed for the course, and places it into the lesson details. The students are expected to read the curriculum thoroughly.

3.2 Conceptual Class Diagram

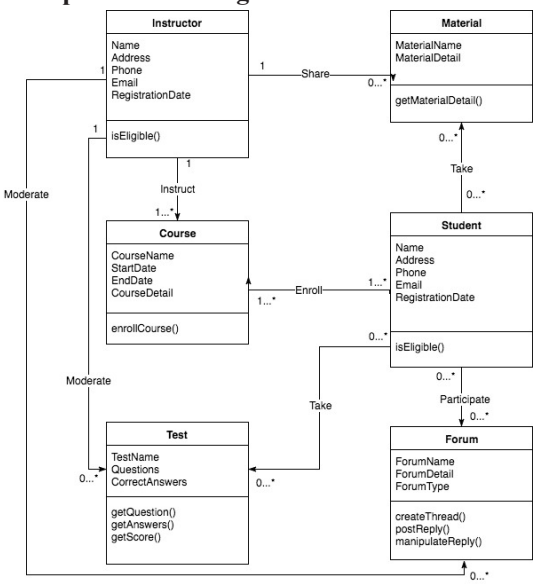

Figure 7. Conceptual Class Diagram of E-Learning for TBL

Figure 7 Explains the conceptual class diagram of E-Learning for TBL to further understand the flow and the connection between each feature in the application.

3.3 E-Learning Development

After the finalized model was created, the website development begun. The website is developed using Wordpress CMS with Eduma to support the E-Learning feature because it highly supports the development of LMS with its specific features. Some plugins were installed to fully integrate the mapped initial requirements

3.4 Application Showcase

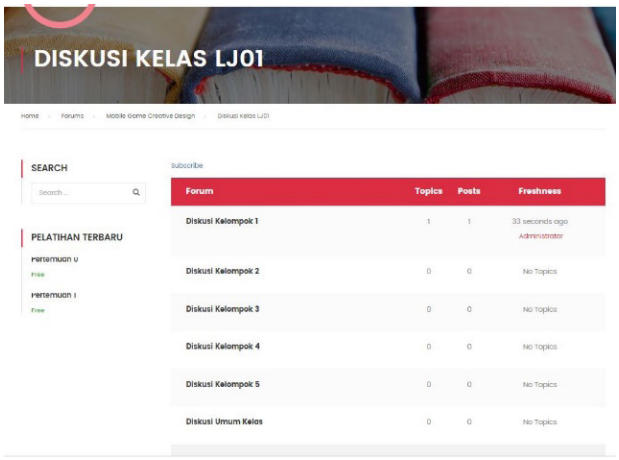

Figure 8. Class and Team Forum Screenshot

forum feature were implemented to further support the e-learning phase of TBL. This feature allows students to interact with each other, from their class or their team. Instructor is also able to monitor and moderate the student conversation.

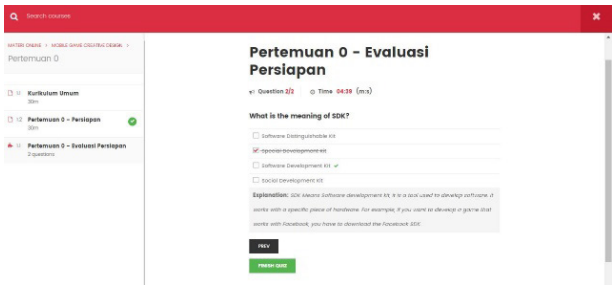

Figure 9. Online Test Screenshot

Online test feature were developed to highly support the immediate feedback aspect of TBL. The students are able to answer the questions given in the specific time allocated, and they will know if the answer is wrong or correct. Detailed explanation is also supported for every number of questions.

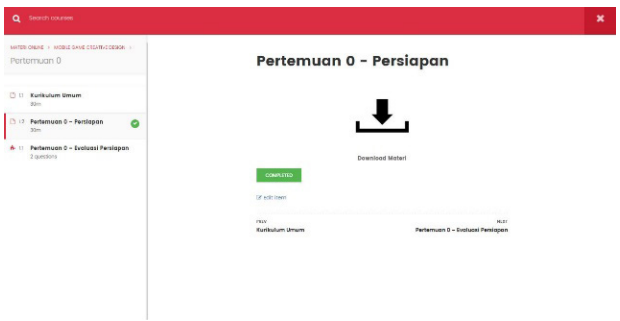

Figure 10. Online Material Screenshot

In the online material feature, it allows the students to be able to download any material given by the instructors. The material can vary starting from presentation, document, link, video or image.

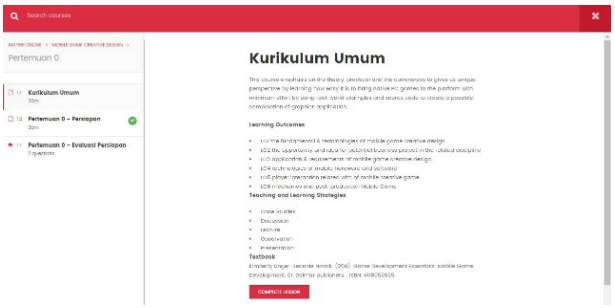

Figure 11. Curriculum Screenshot

This feature was made to support the student in finding out the objective of his study in the specific course

3.5 Application Evaluation

After the development phase, the finished application was tested to 5 participants in an FGD. All participants were involved in the pre-test, experiment, and post-test process. The participants were asked several questions with the main motive to elaborate perceived usefulness of the application in terms of increasing their motivation, engagement, and academic achievement.

The data gathering in this process was conducted both quantitatively and qualitatively with semi directed group interview. The participants were firstly given information and basic description about each question. Then each question were read in the forum, so that interaction may happen between participant to participant, or participant to instructor. The list of questions and the results can be seen in the Table II.

Table II. List of Questions and Answers

No	Question	Avg
Perceived Usefulness		
PU1	Online TBL improves my motivation	5
PU2	Online TBL improves my engagement	4.8
PU3	Online TBL improves my academic achievement	5.6
Perceived Ease of Use		
PEU1	I think that learning with Online TBL is easy for me	4.8
PEU2	I think that it is easy to get the Online TBL to do what we want it to do	4.8
PEU3	I think that interacting with Online TBL is clear and understandable	5
PEU4	I think it's easy to become skillful at Online TBL	4.6
PEU5	I think it's possible to use Online TBL without expert help	3.8
PEU6	Overall, I think that Online TBL is easy to use	5.2
Attitude Towards Using		
AU1	I think that using Online TBL is a good idea	5.2
AU2	I think that using Online TBL is a wise idea	5
AU3	I think that using Online TBL is a positive idea	5
AU4	I like the idea of using Online TBL	5.2
Behavioral Intention to Use		
BU1	It is possible that I will use or continue using Online TBL	5.6
BU2	I intend to begin or continue using Online TBL	6.2

BU3	I will frequently use Online TBL	5.2
BU4	I will recommend others to use Online TBL	6.2

The discussion lasted for 52 minutes in total, with active participation. A lot of follow up questions were asked. First, the participants were given the feature list and the benefit of the Online TBL. Next, the participants were asked individually to try out the system per featured followed by overall testing for 20 minutes. They are able to ask any questions at any point of the tryout. After they had finished testing the system, they are gathered to start the group discussion.

In the group discussion, the participants were not given the answer sheet yet until the discussion is finished. The instructor was the only one with answer sheets. The instructor then started to ask the question one at a time, while collecting and taking note of the answers and questions. After the instructor finished asking one question, the participants are asked to answer one by one. The participants are allowed to ask follow up questions in regards of the initial question. Sometimes the participants asked for a further explanation about the questions, or asking to check the system to confirm the feature description. The instructor provided a laptop for feature confirmation in the group discussion.

All five participants responded almost all features positively. One notable insight is that they might not be used to it, because according to some of them, similar implemented feature in their current LMS, Binusmaya, is barely used. This might be because they are too familiar with in-class learning, where they simply have to come in to class and listen. They might be given homework, but mostly they were not.

Another notable insight, they really think that they really want to recommend the blended TBL to their colleague, and they said that it might be really successful to revolutionize learning process only if it is implemented correctly, and if the lecturer and the university is fully engage in the process.

IV. CONCLUSION

This paper explores the implementation of electronic Team-Based Learning (e-TBL) as a hybrid educational solution, which combines traditional Team-Based Learning (TBL) methodologies with electronic platforms to enhance collaborative learning experiences. The study aims to assess the effectiveness of e-TBL in improving knowledge acquisition, teamwork skills, and overall academic performance among computer science students. The research was conducted in five comprehensive phases, including preparation, experimentation, and evaluation, with a particular focus on developing an e-learning application integrated with the Moodle platform. The findings of the study indicated significant improvements in student motivation, engagement, and academic achievement due to the implementation of e-TBL. Additionally, the study highlighted the increased interaction and collaboration among students, which contributed to a deeper understanding of the course material.

The conclusion confirms that the research problem was effectively addressed. e-TBL proved to be an effective educational strategy, enhancing learning outcomes in both traditional classroom and online learning environments. The study validates the potential of e-TBL in fostering a more interactive and engaging learning experience, confirming its adaptability and effectiveness across various educational settings.

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