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Fostering Metacognitive Skills and Learning Motivation Through Hybrid Learning with Innovative Learning Strategies

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Abstract: The integration of technology into instruction is essential to address teachers' challenges in delivering biology content with greater clarity and depth. This process can be effectively guided by Technology, Pedagogy, and Knowledge Content (TPACK) framework. Grounded in this framework, this study aims to develop valid, practical, and effective hybrid learning resources for biology classes, specifically in the form of lesson plans, assessment tools, and Moodle-based e-learning materials. To achieve this, this study designed and implemented a GITTW strategy that combines Group Investigation (GI) and Think Talk Write (TTW) strategies. This study employed a Research and Development (R&D) methodology using the Four-D model: Define, Design, Develop, and Disseminate. A total of 80 tenth-grade students from Muhammadiyah 3 Senior High School at Surabaya, Indonesia participated in the study. Prior to implementation, the GITTW underwent validation and was deemed valid. Its practicality was supported by data from a student learning independence. This study found that the GITTW lesson plans, assessment forms, and Moodle-based e-learning materials were valid, practical, and effective in enhancing students' metacognitive skills and learning motivation. These results confirm the feasibility of integrating the GITTW strategy into Moodle for biology education to support the development of students' metacognitive skills and motivation. Further studies could explore the integration of GITTW with augmented reality (AR) to facilitate a more in-depth exploration of biology content.

Keywords: *metacognitive skills, learning motivation, hybrid learning, innovative learning.*

Introduction

The rapid development of 21st-century technology has had a profound impact on the field of education, making the integration of technology into learning not only beneficial but essential. One widely recognized framework that supports this integration is Technological Pedagogical Content Knowledge (TPACK), which highlights the interplay among technology, pedagogy, and content in effective instructional design. A thorough understanding of the complex relationships among these three domains is critical for meaningful technology integration in the classroom (Tanak, 2020). The foundation for this integration was laid by NACOL (North American Council for Online Learning), which introduced a learning model that combines face-to-face (offline) instruction with online learning supported by web-based technology (e-learning). This model leverages internet-based platforms that enable students to access learning materials anytime and anywhere (Bahri et al., 2020; Sibley et al., 2024)

Hybrid learning is an emerging instructional approach that corresponds to the model proposed by NACOL. It integrates technology and internet-based to enhance student's learning experience while supporting teachers in improving their teaching methods (Türkmen, 2024). It combines face-to-face learning and electronic learning conducted simultaneously (Min and Yu, 2023; Sukiman et al., 2022). A key feature of this approach is strong student engagement, which serves as a prerequisite for effective learning out-

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comes (De Bruijn-Smolders and Prinsen, 2024). Teachers who implement this approach are also actively involved in course design and interaction with students, facilitating a more responsive and dynamic learning environment (Bozkurt, 2022; Raes, 2022).

The approach also places particular emphasis on the use of Learning Management Systems (LMS) to support and enhance teaching and learning processes (Gamage et al., 2022). LMS enables the delivery of learning content without requiring face-to-face interaction, using either intranet or internet networks (Shchedrina et al., 2021). The integration of LMS in hybrid learning is both feasible and has the potential to enhance student engagement, collaboration, and overall learning experiences. However, several factors must be considered to ensure successful implementation. According to Chiu (2021, 2022), teacher effectiveness and the availability of digital support are critical, as these elements significantly influence student engagement, which can vary across face-to-face and LMS-supported learning environments. Similarly, Mohd Mushtaq and Zahir Iqbal,(2024) highlight the critical role of technology infrastructure in supporting successful implementation. Addressing these factors, Busara Niyomves et al., (2024) argue that hybrid learning can offer the flexibility of online education while retaining the interpersonal benefits of in-person instruction, thereby meeting a wide range of learning needs and schedules.

Moodle is one of the widely used LMS that offers siginicant benefits for hybrid learning environment. It is a software package specifically designed to facilitate the development of internet-based programs and websites. According to Aikina and Bolsunovskaya, (2020), Peramunugamage et al., (2020), and Gamage et al., (2022), Moodle is an effective learning platform due to its interactive features, the integration of multimedia content, and the opportunities it offers for student collaboration. Additionally, Chang et al., (2022) highlight that Moodle supports the delivery of electronic materials, learning media, structured learning paths, and assessments, all of which contribute to increased learning efficiency. Goyal et al., (2023) further emphasize that the implementation of Moodle enhances the quality of learning, increases student interest, and boosts motivation, factors that positively influence learning outcomes. Similarly, recent scholarship by Raman et al., (2022), Gudkova et al., (2021) and Mustapha et al., (2023) indicate that the effective use of Moodle is strongly influenced by students' intrinsic motivation. In this regard, fostering student motivation in biology education is essential, as it plays a critical role in improving learning outcomes.

Biology instruction at the high school level involves the study of complex conceptual material related to processes in the human body, animals, plants, and various natural phenomena. Teachers often encounter challenges in delivering these concepts comprehensively due to limited instructional time. Typically, biology lessons are allocated only two meetings per week, consisting of two class hours (2x45 minutes) and one class hour (1x45 minutes) on separate days. Given the abstract and dynamic nature of biological processes, students require more than verbal explanations: these concepts must also be visualized using instructional media such as videos, diagrams, or interactive images. Furthermore, students are expected to be active and autonomous, capable of seeking additional information and solving problems using online resources. The implementation of hybrid learning through platforms such as Moodle offers a promising approach to address these challenges. It can enhance student motivation, foster active participation, and support self-regulated learning by allowing students to access learning materials flexibly and interactively beyond the constraints of classroom time.

The implementation of hybrid learning should be optimized through the integration of instructional models that actively support students in developing problem-solving skills. One such model is the Group Investigation integrated with the Think-Talk-write (GITTW) strategy, a cooperative learning approach whose syntax includes identifying topics, organizing groups, planning tasks, investigating, analyzing, presenting, and evaluating results, while integrating the "think, talk, and write" processes at each stage (Listiana, 2016 from Sharan and Sharan, 1992 and Huinker and Laughlin, 1996). Each phase of the GITTW strategy is designed to foster students' self-regulation by encouraging them to plan tasks and select appropriate learning strategies independently. Both the group Investigation (GI) and Think-Talk-Write (TTW) components emphasize collaboration, requiring students to work cooperatively in completing tasks. Moreover, this model encourages students to engage in self-assessment and self-monitoring, which are essential aspects of self-regulated learning.

Within the GI component of GITTW, students are guided to work collaboratively in groups. According to Mitchell et al., (2008), this stage involves formulating questions or identifying problems, as well as selecting appropriate procedures for monitoring and assessment. Tsoi et al., (2004) noted that the IG approach encourages students to take an active role in determining what and how they learn. In the final

stage of GI, students collaborate to draw conclusions, develop strategies for presenting their findings, and evaluate their group's performance. Meanwhile, in the TTW component of GITTW, the "think" stage is intended to strengthen students' critical thinking skills. This stage plays a crucial role as students identify problems, determine suitable strategies, and develop plans for problem-solving. The "talk" and "write" stages are reflected in students' presentations and group discussions of their solutions. Through these integrated activities, the GITTW strategy is expected to cultivate students' independent learning skills and promote deeper engagement in the learning process.

Previous studies have demonstrated the potential of the GITTW strategy to enhance students' metacognitive skills. For instance, Listiana, et al. (2016) reported that the GITTW approach significantly contributes to the development of metacognitive skills, while further research from Listiana et al. (2020) showed improvements in students' self-regulation, which in turn positively influenced their learning outcomes. Both GI and TTW components within the GITTW framework share a common goal: cultivating metacognitive awareness. This enables students to plan appropriate problem-solving strategies, regulate their learning process, and assess their own work effectively. Moreover, Listiana, et al. (2023) found that the six syntactical stages of the GITTW strategy effectively enhance students' critical thinking and collaboration skills.

In the context of hybrid learning, the development of metacognitive skills is essential, as students are required to plan, monitor, and control their learning processes to achieve optimal outcomes. Fayaza and Ahangama (2024) argue that in blended learning environments**,** self-directed learners are more likely to achieve improvements in cognitive, metacognitive, and motivational learning domains. Similarly, Essa, (2023) asserts that hybrid learning ha a strong positive correlation with the development of deep learning competencies. Acosta-Gonzaga and Ramirez-Arellano (2021) further emphasize the relationship between cognitive and metacognitive strategies and students' motivation in blended learning contexts. This is supported by Monika and Devi (2022) , who found that blended learning enhances student engagement, interaction, academic achievement, motivation, and the overall learning process.

Considering the challenges identified, students' limited understanding of biological processes in the human body, teachers' difficulties in delivering detailed explanations, and the underutilization of technology in biology instruction, it becomes crucial to integrate technological tools in meaningful ways. One potential solution involves the use of Moodle-based media within a hybrid learning model, supported by an innovative instructional strategy such as GITTW. Therefore, this study aims to develop a comprehensive instructional package, including lesson plans, student worksheets, evaluation tools, and Moodle-based e-learning media (accessible via https://tacticedu.com), that is valid, practical, and effective for teaching biology. Although previous studies have explored the use of Moodle in e-learning, this study adopts a distinct approach by integrating Moodle with the GITTW strategy, which is expected to promote students' metacognitive development and support their growth as independent learners.

Materials and Methods

This study employed a Research and Development (R & D) study, following the Four-D development model proposed by Thiagrajan (1974)**,** which consists of four stages: Define, Design, Develop, and Disseminate**.** The primary objective of this study is to produce instructional materials**,** including lesson plans, student worksheets, evaluation sheets, and moodle-based e-learning media (accessible by https://tacticedu.com), that are valid, practical, and effective for learning.

Sample and Data Collection

This study was conducted with 10th-grade students at SMA Muhammadiyah 3 Surabaya**.** It employed a saturated sampling technique, involving the entire population of Grade 10 students, consisting of 80 active learners enrolled in the biology subject. This sampling method was chosen based on the relatively small number of students in Grade 10, making it feasible to include all participants. The study implemented a hybrid learning model integrated with the GITTW strategy, using Moodle-based media, adhering to the structured learning syntax designed for this model. The biology topics covered included virus structure, replication processes, and the role of viruses in life.

Research Instrument Validity, and Reliability

The instruments used were questionnaires, validation assessment sheets, product practicality evaluation sheets, and product effectiveness tests**.** The data collection techniques employed were: (1) The validity of the instructional materials, including lesson plans, student worksheets, evaluation tests, and Moodle-based media, was assessed using validation sheets by 3 experts. (2) The reliability of the instructional materials was tested using Cronbach's alpha, with the results interpreted based on the levels of reliability categorized as very high, high, moderate, or low. (3) Practicality data were collected through questionnaires to gather students' and teachers' responses regarding the use of Moodle-based e-learning. (4) The effectiveness of the product was evaluated using essay tests that incorporated indicators of metacognitive skills (Corebima, 2006)**.** (5) Data on students' learning motivation were obtained through a motivation questionnaire.

Research Procedure

The research procedure consisted of the following stages: (1) Define: This step included several steps: front-end analysis, task analysis, learner analysis, concept analysis, and learning objectives analysis. (2) Design**:** This step involved selecting instructional media, choosing the appropriate format, developing the product, and preparing instructional materials for face-to-face learning. It also included preparing e-learning media (Moodle) and designing the initial Moodle framework within a hybrid learning model integrated with the GITTW strategy. (3) Develop**:** This step focused on developing instructional materials and the Moodle platform within the hybrid learning model integrated with the GITTW strategy, which was validated by three experts (validators). This was followed by product testing to evaluate the quality of the Moodle-based hybrid learning model for biology subjects, and (4) Disseminate**:** This final step involved large-scale experimental implementation, which is planned for the subsequent academic year.

Analyzing of Data

The data analysis technique employed both inferential and descriptive statistical analyses. The analyses were carried out as follows: (1) feasibility validation was conducted through scoring, followed by percentage calculation, and then categorized according to validity levels based on Hobri (2009), as follows: strongly valid (4.6 to 5), valid (3.6 to 4.5), less valid (2.6 to 3.5), invalid (1.6 to 2.5) and strongly invalid (less than 1.6). (2) The data related product practicality, Moodle-based e-learning, were gathered using questionnaire from student and teacher. The responses were analyzed quantitatively using percentage and categorized according to Arikunto (2002) as very practical (84%-100%), practical (68%-83%), quite practical (52%-67%), less practical (36%-51%), and impractical (less than 35%). (3) The effectiveness data were analyzed descriptively quantitatively using N-gain score based on (Hake, 199 C.E.), an N-gain score ≤ 0.30 indicates low improvement, 0.30 < N- gain ≤ 0.70 indicates moderate improvement, and 0.70 < N-gain ≤ 1.00 indicates high improvement. (4) Student learning motivation was measured using a questionnaire adapted from the ARCS (attention, relevance, confidence, and satisfaction) model of Keller (1987). The questionnaire used a Likert scale consisting of very agree, agree, disagree, and very disagree.

Results

This study developed a Hybrid Learning model integrated with GITTW strategy, comprising lesson plans, student worksheets, evaluation sheets, and GITTW-integrated Moodle-based e-learning media. The learning model involved a combination of e-learning and face-to-face learning. The educational media product (Moodle) produced was in the form of a website, taxticedu.com, and its implementation was based on the GITTW strategy syntax. The research development model was the 4D development model (Four-D Models).

A. Define Media Moodle

At the define stage, the analysis of tasks revealed that the assignments provided by teachers did not adequately support independent learning. Students had limited opportunities to explore information in depth, and the flexibility of tasks was minimal, resulting in constraints related to time and collation for

task completion. Furthermore, the methods for accessing tasks remained conventional, and the types of assignments lacked variation, particularly in addressing diverse student learning styles. In the context of blended learning, task design must prioritize accessibility, diversity, and flexibility. Through the integration of e-learning media, tasks can be differentiated to accommodate various learning preferences, enabling students to complete assignments anytime and anywhere without restrictions.

The student analysis considered gendered distribution and initial competencies related to the learning topic of viruses. Findings indicated that students' prior knowledge of the subject matter was insufficient, and foundational understanding was limited. Students exhibited a range of learning styles, visual, auditory, kinaesthetic, or mixed learning styles, which provided valuable insights for the design of instructional materials and media. Additionally, students' motivation and interest in learning were found to be low and in need of reinforcement. Another significant challenge was students' limited proficiency in using technological devices, which stemmed from the restricted availability of laptops, tables, or smartphones, along with limited access to the internet and e-learning platforms such as Moodle and Google Classroom.

The concept analysis revealed that the subject matter ranged in complexity from simple to advanced. However, no instructional modules or teaching materials were available that clearly structured and sequenced these concepts to build coherent understanding. Instructional delivery remained largely conventional with limited access to supplementary resources. Therefore, the development of interactive e-learning media is crucial. Media such as videos, infographics, animations, and simulations can enhance students' understanding and allow them to access complex content more independently and effectively.

Although the existing learning objectives encompassed cognitive, affective, and psychomotor domains, they did not clearly reflect the targeted competencies. Several objectives lacked alignment with instructional activities and media, resulting in weak learning outcomes. Thus, it is essential to develop e-learning media, particularly using Moodle, as a flexible and adaptive platform. This approach can accommodate diverse learning styles while enabling educators to present instructional content in a dynamic, interactive, and competency-oriented manner.

B. Design Media Moodle

The Moodle media developed based on several criteria is shown in Table 1.

Table 1. *Moodle development design*

	Development Design
Design Name	Hybrid Learning integrated with GITTW strategy
Sponsor	DRPM Grant
Needs	innovative learning media to enhance learning motivation and metacognitive skills
Reasoning	Most schools do not yet have Moodle-based e-learning media that supports hybrid learning.
Expected results	Hybrid learning integrated GITTW strategy with media moodle is valid, practical and effective.
Customer	Students who study in SMA Muhammadiyah grade X, Surabaya.
Design's aim	Producing valid, practical, and effective lesson plans, student worksheets, evaluation sheets, and Moodle-based e-learning as innovative learning media and resources that can enhance learning motivation.
Knowledge, skills and abilities of customer	Students have knowledge, skills, abilities in operating computers, laptops, and mobile phones, making it easy for them to adapt to the Moodle platform
Feedback	Students can be motivated to learn, becoming independent learners to construct knowledge. Helping teachers as a learning medium that supports hybrid learning
Benefits	The design produces innovative media and learning resources that facilitate students and teachers in hybrid learning.

The design format of the developed moodle e-learning consists of features presented in Table 2.

Table 2. *A design of moodle*

Component of e-learning	Sub Component of e-learning
Hompepage (log-in page)	Name of e-learning, log in of account, and information of e-learning
Main page (Dashboard)	Site home, calendar, course name, timeline, and upcoming events
Site home	Available course name
Course page	Participants, introduction, pre-test, content competence, basic competence, learning objectives, material content, forum discussion, student worksheet, quiz, and score

C. Development Moodle

Moodle and the accompanying instructional tools, including evaluation sheets and lesson plans, are products specifically developed to support hybrid learning. The outcomes of the Moodle-based hybrid learning model can be observed through several key components: (1) the front page (login page), (2) the main page (dashboard), and (3) the course page. In this hybrid-based learning environment, all sessions were conducted online for students who were unable to attend in person (outside the classroom), while face-to-face instruction was provided for those present in class. Moreover, the Moodle-platform offers a range of learning recourses, including condensed learning materials, instructional videos, and external resource links. Each session incorporated interactive features such as discussion forums, chat functions, assignments, quizzes, and attendance tracking. Assignments and assessments were designed to be completed within a specific time frame, encouraging student responsibility and time management. These features were strategically integrated to meet the pedagogical needs of both teachers and students throughout the teaching and learning process.

The Moodle platform, accessible view https://tacticedu.com, has been equipped with user manual tailored both for teachers and students. These guides are protected by copyright and serve as practical references to facilitate the effective use of the platform. Figure 1 shows the main interface of the developed Moodle system.

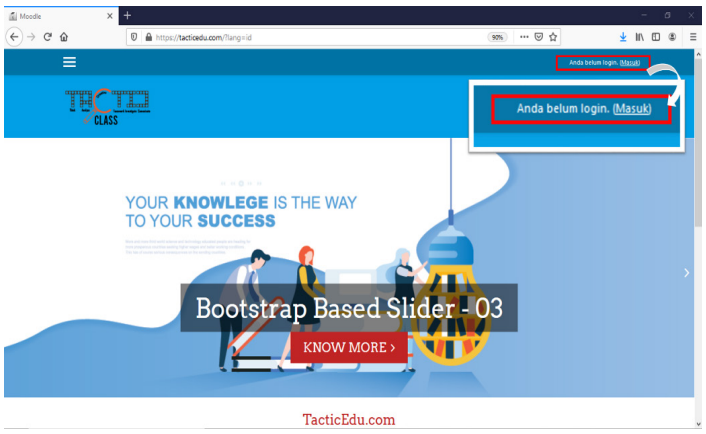

Figure 1. Front page view of moodle http://tacticedu.com

The developed product consisted of a Moodle-based learning and supporting e-learning resources. The resources included lesson plans, student worksheets, evaluation sheets, and validation instruments. The product was evaluated by three expert validators to ensure its quality and relevance. Validation was carried out through a comprehensive review of the developed components. This product was validated by three expert validators. Validation was conducted by reviewing the developed product. Furthermore, the validity of the Moodle-based learning platform and its associated learning recourses was assessed using the validators' evaluation, with the results presented in Table 3 through 8. The validation results for the lesson plan yielded an average score of 4.41 across several evaluation aspects. This score falls within the "valid" category, as shown in Table 3.

Table 3. *Result of the validation of the lesson plan*

Aspect	Average Scores	Category
The identity of lesson plan	5.00	Strongly valid
The time allocation	4.00	valid
Learning achievement competencies include attitudes, knowledge and skills	4.25	valid
Development of course material	4.33	valid
The alignment between the learning model used and the learning steps	4.00	valid
The method learning can used based on suitability with the characteristics of the objectives, situation, and conditions.	4.00	valid
Accuracy Learning steps	4.33	valid
The assessment is based on certain indicators and criteria	3.50	less valid
The Reference can used in the preparation of student worksheets and course material	4.50	valid

Table 3 shows that all aspects of the lesson plan were categorized as valid to highly valid, with exception of one aspect classified as “less valid”, namely “the assessment is based on certain indicators and criteria,” which received an average score of only 3.50. This finding is noteworthy, as it suggests that although the lesson planning was well-structured in terms of identity, content, and instructional methods, the assessment component remained a critical weakness. This may indicate the need for improvement in formulating evaluation indicators that are both appropriate and meaningful in relation to the learning objectives and the metacognitive skills aimed to be developed.

The results of the validation from three expert validators on the student worksheets yielded an average score of 4.06, which is classified as “moderately valid”, as presented in Table 4.

Table 4. *Results of the validation of student worksheet*

Aspect	Average Score	Category
Content: the alignment of basic competencies with core competencies, the alignment of indicators and learning objectives, the alignment of objectives with tasks	4.50	strong valid
Presentation: relevance of the topic to the material, coherence of the material, and supporting student assignments	4.00	valid
Language: A communicative, simple, and easy-to-understand language	4.00	valid
Display: accuracy of image layout, presentation clear and easy To understand	3.75	valid

Table 4 shows that the content aspect of the student worksheets received the highest score (4.50), falling into the “strongly valid” category. This indicates that the primary strength of the worksheets lies in the alignment between indicators, objectives, and learning activities with the core competencies. However, another notable finding concerned the display aspect, which received the lowest score (3.75) among all evaluated components. Although still categorized as “valid,” this suggests that visual elements, such as layout, image placement, and clarity of presentation, require further improvement. In the context of digital learning, effective visualization plays a crucial role in enhancing student engagement and comprehension.

The results of the Moodle validation by three media expert validators yielded an average score of 3.97 across several aspects, as presented in Table 5.

Table 5. *Moodle-based e-learning validity results*

Aspect	Average Score	Category
Layout Proportions (content area, header, and widget)	3.75	valid
Proposal Layout (text and image layout) from the material	3.50	less valid
The suitability of the header design and color proportions	4.00	valid
The suitability of font type and size selection	3.50	less valid
The appeal of the animation presentation, and the suitability of the animation with material	3.00	less valid
A simple and polite appearance (does not contain irrelevant images and objects)	4.00	valid
Ease of use of the program, navigation language and widgets in the program	5.00	strongly valid
Ease of interacting with the program and understanding the navigation structure	4.00	valid
Ease of *login* and *logout* from the program	5.00	strongly valid

Table 5 shows that the aspects of program usability and the login-logout process received a perfect score of 5.00 and were categorized as strongly valid, highlighting Moodle's strength in terms of technical accessibility. However, an interesting finding emerged in the aspect of animation and its relevance to the learning material, which received a score of only 3.00 and was categorized as less valid. This suggests that although Moodle is highly accessible, the quality of interactive visuals such as animations require improvement. Animation is a crucial element in biology instruction, particularly given the subject's inherently visual and procedural in nature.

The result of the course material validation by three expert validators, based on several aspects as presented in Table 6, yielded an average score of 4.3, which falls into the "valid" category.

Table 6. *Course material validation results*

Aspect	Average Score	Category
Scope: breadth and depth of content, structure and sequence content	4.75	valid
Clarity and the appeal of the material in aiding understanding.	4	valid
Clarity of instructions for solving practice questions, question formulation, and difficulty level	4.5	valid
Clarity of Language and information in image illustrations	4	valid

Table 6 shows that all aspects of the course material were categorized as valid, with the highest score recorded in content coverage (4.75). A noteworthy finding emerged from the fact that two aspects, the clarity and attractiveness of the material, as well as the clarity of language and image illustrations, received a lower score of 4. This indicates that although the content is comprehensive and well-structured, there remains room for improvement in visual and narrative presentation to enhance both aesthetic appeal and ease of understanding.

The result of the validation on the evaluation sheet, an integrated metacognitive skills test in the form of an essay questions, conducted by three expert validators yielded an average score of 3.91, which falls within the "valid" category. The scores based on various aspects are presented in Table 7.

Table 7. *Results of the evaluation sheet validation*

Aspect	Average Score	Category
Material Aspect: the alignment of cognitive aspects measured with basic competencies, the alignment of question items with learning objectives and cognitive aspects.	3.75	valid
Construction Aspects: clarity of instructions, assessment rubrics, and formulation of concise sentences	4.00	valid
Language Aspect: Question items with well-structured sentences, communicative sentences, easy to understand, and language that does not contain double meanings.	4.00	valid

Table 7 shows that all aspects of the evaluation sheet are categorized as valid, with the highest score (4.00) achieved in the aspects of construction and language. Another noteworthy finding is observed in the content aspect, which received the lowest score (3.75), although it still falls within the "valid" category. This finding is significant, as the primary objective of an evaluation is to ensure that the assessment accurately represents the competencies intended to be measured. If this alignment is lacking, the effectiveness of learning outcomes measurement may be compromised.

D. Implementation

The implementation of the GITTW-based hybrid learning model using moodle e-learning was carried out at SMA Muhammadiyah 3 Gadung Surabaya, Indonesia, involving 80 students from the Grade 10 Science class during the first semester of the 2023-2024 academic year. The learning process commenced with an orientation on how to use the Moodle application, supported by a previously provided tutorial video. The instructional sessions on the topic of viruses were delivered in three meetings, each lasting 3 x 45 minutes.

The results of the rial implementation of the GITTW-based hybrid learning model through Moodle-based e-learning were valid and reliable, as presented in Table 8.

Table 8. *Test validity and reliability results*

Aspect	Average Score	Category
Validity	0.42 – 0.82	valid
Reliability	0.634	high
Difficulty Index	0.23 – 0.31	average - difficult
Discrimination Index	0.23 – 0.44	good

Table 8 shows that the developed test instrument demonstrates a good validity, ranging from 0.42 to 0.82, and high reliability (0.634), indicating a trustworthy measurement quality. However, a noteworthy finding lies in the difficulty index, which falls between 0.23 and 0.31, categorized as moderately difficult. This suggests that the test items were relatively challenging for most students.

At the Implementation stage, a practicality test of the GITTW-based hybrid learning model integrated with Moodle-based e-learning was conducted. The practicality test involved four teachers who completed a teacher response questionnaire. The results of this evaluation, which reflect the teachers' assessment of the practicality of the Moodle-based e-learning integrated with the GITTW strategy, are presented in Table 9.

Table 9. *Teacher response to moodle-based e-learning*

Aspect	Responses Percentage (%)	Practical Category
Learning Display	88.22	Very practical
Content	77.18	practical
Display	87.98	Very practical
Operation	89.77	Very practical
Language	85.67	Very practical

Table 9 indicates that teachers rated almost all aspects of the Moodle-based e-learning as highly practical, particularly in terms of operational ease (89.77%) and instructional design appearance (88.22%). However, a notable finding appeared in the content aspect, which received a score of only 77.18% and was categorized as practical rather than very practical. This suggests that although the platform was technically well-received, there remains room for improvement in the quality or depth of the instructional content to better align with pedagogical needs and teachers' expectations. The results of the practicality test of the GITTW-integrated Moodle-based e-learning as assessed by students are presented in Table 10.

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Tabel 10. *Student responses to moodle-based e-learning*

Aspect	Responses Percentage (%)	Practical Category
Material suitability	82.11	practical
Display	85.89	Very practical
Operation	80.67	practical
Language	85.77	Very practical

Table 10 shows that the operational aspect received the lowest score (80.67%) compared to other aspects, although it still falls within the practical category. Despite the platform's strong technical features, this result may indicate that some students experienced minor technical challenges or had limited digital skills in operating Moodle effectively. This is particularly relevant in the context of hybrid learning, which demands a higher degree of technological autonomy from students.

Based on the analysis of both teacher and student responses to the GITTW-integrated Moodle-based e-learning, the findings indicate that the developed product is highly practical and ready for implementation.

During the limited trial phase, the effectiveness of the GITTW-integrated Moodle-based e-learning, was evaluated. This was carried out using an essay-type assessment instrument designed to measure metacognitive skills. The results of the effectiveness test are presented in Table 11.

Table 11. *Product effectiveness results*

N-Gain Category	Percentage
Height increase	57.50 %
Medium increase	31.25 %
Low increase	11.25 %

Based on Table 11, an interesting finding emerges in the dominance of the high-gain category, indicating that the product has a significantly positive impact on learning outcomes. This suggests that the intervention provided through the product is highly aligned with the learners' needs and characteristics, enabling the majority of students to gain maximum benefit.

The results of the learning motivation questionnaire, which measures the aspects of attention, relevance, confidence and satisfaction, are presented in Table 12.

Table 12. *Student learning motivation results*

Category	Percentage
Very agree	37.50
Agree	51.25
Disagree	11.25
Very disagree	0.00

Table 12 shows that no respondents chose the "very disagree" category (0.00%), indicating that all participants responded positively to their learning experience. This reflects that the learning approach or media used was not only effective but also emotionally and cognitively accepted by students, creating a learning environment that supports internal motivation.

Discussions

This study developed a hybrid learning model integrated with the GITTW strategy and supported by educational materials, including lesson plans, student worksheets, evaluation instruments, learning motivation observation sheets, questionnaires, and a Moodle-based e-learning platform. All instructional materials were valid, effective, and practical. The classroom implementation of the Moodle-based e-learning system demonstrated improved student engagement and enthusiasm, facilitated by smartphone usage to access the Moodle application, where students independently searched for information to solve learning problems.

The Moodle-based e-learning platform can be accessed through http://tacticedu.com. This platform provides various learning resources, including biology materials, images, videos, animations, and learning activities for each session, such as attendance, discussion forums, chats, assignments, and quizzes. These features are designed to simulate active student engagement. The assignment feature, in particular, fosters students' ability to search the internet for problem-solving information, thus supporting innovative learning. As noted by Rasheed et al., (2020), innovative learning can be effectively achieved by combining content and resources from both face-to-face and online learning modalities.

Survey results indicate highly positive responses from both teachers and students toward the Hybrid Learning model integrated with GITTW strategies and the developed Moodle-based e-learning.

Teachers noted that the Moodle platform is visually engaging and provides content that effectively supports classroom instruction. It enables teachers to align their teaching with the planned model syntax and serves not only as a medium for content delivery but also as a platform for assigning and managing student tasks. Teachers also reported that Moodle facilitates content delivery both in-class and beyond, supporting the hybrid learning approach.

Student survey results also reveal increased interest and engagement in learning activities. The multimedia factures such as images and videos make the content more comprehensible and appealing. Students collaborate in groups with clearly defined roles, each utilizing Moodle via smartphones to complete tasks. The flexibility of the hybrid learning model allows students to self-direct and regulate their learning activities. This aligns with findings from de Oliveira et al., (2022), who argue that Moodle enhances active student engagement, fosters self-regulation, and promotes learner autonomy. Similarly, Chiu (2021), asserts that digital tools play a critical role in supporting student participation in hybrid learning environments.

The hybrid learning encourages students to stay motivated and engaged, especially when they can access video presentations via Moodle to reinforce understanding. This method helps students develop confidence and persistence in addressing complex problems. The e-learning platform also enables direct submission of assignments, eliminating the need for physical printing. The integration of interactive multimedia via Moodle has proven to increase students' learning motivation. Research by Helena and Deborah (2024) emphasizes that platforms such as Moodle significantly influence motivation due to their accessibility, interactivity, and flexibility, which align with students' talents and interests. This is supported by Frisnoiry and Darari (2020), who found that the use of Moodle substantially affects student motivation.

While Moodle supports both online and offline learning environments, it requires structured learning strategies to help students focus on understanding and solving problems scientifically. The GITTW strategy enhances this process by guiding students through investigation, solution planning, and the identification of optimal outcomes, all of which are facilitated by internet access and Moodle features. Mustapha et al. (2023) highlight that the integration of Moodle with structured learning strategies improves motivation and fosters positive learner perceptions. Similarly, Gamage et al. (2022) state that Moodle enhances the speed and efficiency of information retrieval, contributing to effective problem-solving. Thus, incorporating learning strategies within Moodle provides clear direction in achieving educational objectives.

The GITTW strategy adopted in this study is a cooperative learning model that emphasizes student autonomy, encouraging learners to take responsibility for planning and managing their own learning processes. It supports the development of independent learning skills. The structured syntax of GITTW in Moodle-based instruction guides students through stages of identifying problems, task delegation within groups, conducting investigations, analyzing solutions, and concluding with self-assessment to reflect on learning processes and outcomes (Listiana et al., 2020). Through this process, students are trained to work independently, collaborate in teams, solve problems, and take ownership of their learning, skills linked to the enhancement of metacognitive skills.

Above all, the integration of educational technology is vital for fostering self-regulated and independent learning. The interactive Moodle platform enables teachers to facilitate deeper student engagement. When paired with metacognitive guidance, students learn to plan, monitor, and evaluate their learning strategies to achieve goals in a hybrid learning context. The development of instructional materials integrating the GITTW strategy significantly support this model of learning. Listiana et al., (2023) emphasize that GITTW strategy promotes self-assessment and reflection and can be effectively applied in both online and face-to-face learning environments.

Conclusions

This study aims to develop a hybrid learning educational tool by integrating the GITTW strategy into instructional components, including lesson plans, evaluation sheets, and e-learning media like Moodle for the biology subject at the senior high school level. The results demonstrate that the developed products were valid, effective, and practical as they showed the potential to enhance students' metacognitive skills and learning motivation. These educational media are expected to support teachers in improving the quality of biology instruction and can be widely applied to other subjects, provided that the unique characteristics of both learners and subject matter are taken into account. Future studies could explore the development

of Moodle by integrating Augmented Reality (AR), enabling students to learn about and explore the human organ systems interactively. Through AR-enhanced learning, students would be able to access textual materials, watch instructional videos, and activate 3D models of human organs directly from their smartphones.

Limitations

This study has four limitations. First, the sample size was limited to 80 tenth-grade students from a single private school in Surabaya, Indonesia, which constraints the external validity and generalizability of the findings to a broader population. Moreover, the specific research context, characterized by uneven digital infrastructure, revealed that not all students had adequate access or sufficient skills to operate the Moodle platform, as indicated by the relatively lower operational response scores from students. Second, although Moodle was perceived as highly practical by both teachers and students, the effectiveness test was conducted on a small scale without a comparison group or a more robust experimental design. As such, it remains uncertain whether the observed improvements in learning outcomes were solely attributable to the intervention. Third, the data collected were predominantly quantitative, relaying on questionnaires, without the support of in-depth qualitative data such as interviews or observations that could provide a more holistic understanding of the learning experience. Fourth, the sustainability of Moodle use beyond the research phase was not evaluated. Therefore, further studies are necessary to investigate the broader and long-term implementation of Moodle in diverse educational settings.

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Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization, L.L., F.R. and R.D.; methodology, R.D. and A.S.H.; formal analysis, F.R.; writing—original draft preparation, L.L.; writing—review and editing, L.L., and F.R.; Supervision, A.S.H. All authors have read and agreed to the published version of the manuscript.

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