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Digital Teaching Material of Integrated Science with Blended-PBL Model for Independent Curriculum

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Abstract: The Independent curriculum demands student-centered learning by utilizing technology, so that students' 21st century skills can develop. However, what is found at school is very contrary to the demands of learning in the independent curriculum. As a solution, Digital Integrated Science Teaching Materials Integrated Blended-PBL Model (DTMIS-Blended-PBL) was developed for the development of the Independent Curriculum. This research aims to determine the needs analysis, validity, and practicality of integrated digital science model teaching materials with PBL models. The research method used is the development method with the Ploomp. Research data in the form of knowledge scores, creative thinking skills, and communicative skills of students, validity and practicality of DTMIS-Blended-PBL. Based on the research results, three conclusions can be presented. First, there are problems in learning, especially low student achievement and creative and communicative thinking skills. Second, DTMIS-Blended PBL is valid with an average score of 0.87. Third, DTMIS-Blended PBL is practical with an average score of 93.53. Therefore, the developed DTMIS-Blended PBL is valid and practical so it has the potential to improve the quality of science learning and support the implementation of the Independent Curriculum.

Keywords: Blended-PBL model; Digital teaching materials; Independent curiculum; Science

Introduction

The rapid development of digital technology has brought fresh air to the world of education. One of its manifestations is the birth of the Independent Curriculum. The Independent Curriculum is a policy that encourages flexibility and independence in student learning (Fauzan et al., 2023; Rizaldi & Fatimah, 2022). In this context, the development of innovative teaching materials is crucial. One promising approach is the integration of problem-based learning (PBL) models in digital-based integrated science teaching materials (Chua, 2023; Chueh & Kao, 2024; Smith et al., 2022; Trullàs et al., 2022).

Effective science learning focuses not only on mastering concepts, but also on developing students' critical thinking skills, problem solving, and creativity (Astawan et al., 2023; Chen et al., 2024). The PBL model, with its emphasis on authentic problem solving, is very much in line with this goal (Dewi et al., 2023; Hallinger, 2023). When combined with digital technology, the PBL model can provide a more interactive and engaging learning experience for students (Nicolaou & Petrou, 2023; Nurmahasih & Jumadi, 2023; Siripipatthanakul et al., 2023). Effective use of science teaching materials to improve students' 21st century skills (Fitria et al., 2023). PBL model is able to increase learning independence, creative thinking skills, critical thinking, argumentation,

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science process, problem solving and analytical (Nurmahasih & Jumadi, 2023).

Integrated science teaching materials play an important role in improving students' understanding of science concepts (Asrizal et al., 2018; Irhasyuarna et al., 2022). The integration of various science concepts in one teaching material allows students to see the connection between various natural phenomena (Bhat, 2023; Park et al., 2023). The relevance of learning materials to everyday life is key to increasing students' learning motivation (Almulla, 2023; Filgona et al., 2020). By connecting science concepts with real contexts, students can more easily understand and remember the material they have learned (Abdullah et al., 2022; Dewi et al., 2022). Therefore, the development of integrated science teaching materials that are relevant to the context of students needs to be carried out continuously to improve the quality of science learning.

The integration of the blended-PBL model in digital integrated science teaching materials offers a number of advantages. First, flexibility in learning allows students to learn at their own pace (Al-Abdullatif & Gameil, 2021; Lukitasari et al., 2019). Secondly, the use of digital technology can enrich the learning experience with various media such as videos, simulations, and games (Kokoç, 2019; Nurhidayah et al., 2021). Third, collaboration between students can be more easily facilitated through digital platforms (Gopinathan et al., 2022; Guerrero-Quiñonez et al., 2023). However, developing quality teaching materials is not an easy task. Some important questions that need to be answered such as: whether the teaching materials developed have met the expected learning objectives. How valid are the assessment instruments used and the teaching materials developed?. How practical are these teaching materials when applied in the actual context?

To answer these questions, it is necessary to conduct an in-depth analysis of the teaching materials that have been developed. This analysis includes aspects of introduction, validity, and practicality. The preliminary aspect relates to the extent to which teaching materials are designed based on learning theories that are relevant to student needs (Lockey et al., 2021; Yani et al., 2020). The validity aspect relates to the extent to which the assessment instruments used can measure what should be measured (Schaufeli et al., 2020; Surucu & Maslakci, 2020). While the practicality aspect relates to the ease of use of teaching materials by teachers and students and their suitability for available resources (Haleem et al., 2022; Trullàs et al., 2022).

The novelty of this research emphasizes the unique combination of digital technology integration, innovative learning models, and implementation in the context of the still-evolving Independent Curriculum. First, the development of digital-based teaching materials. Although digital teaching materials have been used frequently, the combination of integrated science content with the Blended-PBL learning model in one digital platform provides a new contribution. This research offers a solution designed to maximize digital technology in science teaching, which is interactive and encourages student collaboration online and offline. Second, the integration of the Blended-PBL model in the context of integrated science. This research integrates two innovative approaches in education, namely Blended Learning and Problem-Based Learning into integrated science materials. The novelty lies in how these two models are applied to complement each other which has not been widely integrated in digital teaching materials, especially in the context of the Independent Curriculum. Third, the development of this teaching material is also specifically designed to support the objectives and principles of the Independent Curriculum.

This article aims to present the results of an in-depth analysis of the development of integrated digital science teaching materials integrated with the blended-PBL model (DTMIS-Blended PBL) in the context of the Independent Curriculum. The results of the analysis that will be presented are in terms of needs analysis, validity, and practicality of DTMIS-Blended PBL. Through the results of this analysis, it is hoped that a clear picture of the strengths and weaknesses of the teaching materials developed and the implications for the development of similar teaching materials in the future can be obtained.

Method

The research conducted included experiments conducted in research and development (R&D). The development model in this research refers to Plomp's development model (Plomp & Nieveen, 2010). The research procedure consisted of three stages. However, this research is limited to the second stage. First, the preliminary research stage is useful for analyzing the problems found at school and finding the right solution. Second, the development or prototyping stage. At this stage, the validity test and practicality test of the product are carried out. Furthermore, the product is revised according to the validator's suggestion and the practicality test is carried out in stages. The stages of practicality carried out consist of one to one evaluation, small group evaluation, and practicality tests in experimental classes. The various stages of Plomp systematic educational design model can be seen in Figure 1.

The data used are data on learning problem analysis, validity, and practicality. The instruments used to analyze learning problems are document analysis sheets and performance assessment sheets. Document analysis was carried out by collecting data from the entire class and then analyzed with one way anova analysis, so that two classes were obtained for product trials. The instrument used for validity data is a validation sheet. The validation sheet consists of two types, namely self-evaluation which is tested by the researcher himself and expert review which is tested by five experts from FMIPA of Universitas Negeri Padang. The practicality instrument used is a practicality sheet.The practicality sheet used three times, namely the one to one practicality sheet to three students, small group to 9 students, and practicality test to the experimental class.

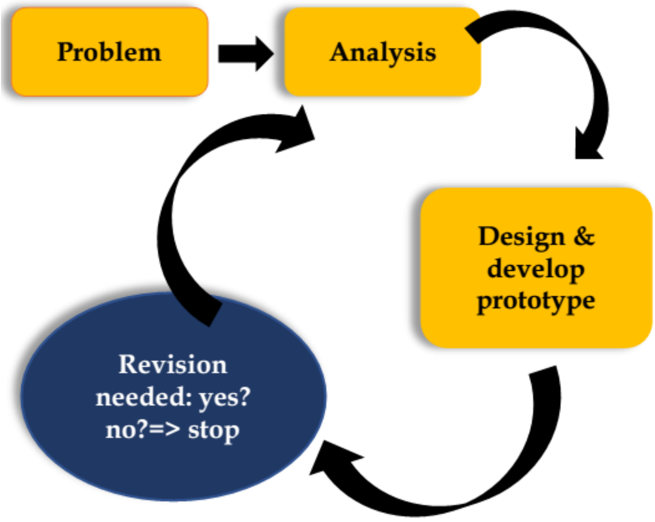


Figure 1. Stage of Plomp model systematic educational design

The assessment of learning problem analysis and product practicality was carried out using Likert scale analysis (Formula 1). The product validity assessment was carried out using the validity calculation, namely Aiken's V (Formula 2). The steps for assessing product validity are giving a score for each indicator between 1-4, summing up the score and then processing the value using the Aiken's V formula. The formulation of the Likert scale and Aike's V is presented in the following explanation.

$$V = \frac{\sum Total\ Score}{\sum Maximum\ Score} 100 \quad (1)$$

$$V = \frac{\sum s}{[n(c-1)]} \quad (2)$$

The description of the formulation is that S is the difference between r and lo. lo is the lowest score (1). c is the highest score (5). r is the score obtained from the validator. Determination of product feasibility after analysis is determined by the validation scale. The validation scale obtained ranges from 0 to 1.00. The validity assessment interval for the range ≥ 0.60 is categorized in the valid category. While the validity assessment interval for the range <0.60 can be categorized in the invalid category (Azwar, 2015). The product validity criteria are shown in Table 1.

Table 1. Validity Criteria

Value	Criteria
≥ 0.60	Valid
< 0.60	Invalid

The determination of the product's practicality value is determined by the practicality scale. The practicality scale ranges from 0 to 100. The product practicability assessment interval is divided into five ranges. If the practicality value is in the range of 0-20, the practicality of the product is very low. If the practicality value is in the range of 21-40, the practicality of the product is low. If the practicality value is in the range of 41-60, the practicality of the product is moderate. If the practicality score is in the range of 61-80, the practicality of the product is high. If the practicality score is in the range 81-100, the practicality of the product is very high.

Result and Discussion

Result

Learning Problem Analysis Results

The research results found consisted of three. First, the results of the analysis of learning problems. Second, the results of the validity analysis of DTMIS-Blended PBL. Third, the results of the practicality analysis of DTMIS-Blended PBL. Each research result is explained in detail as follows.

Initial analysis of the research data revealed significant problems in student learning outcomes. This is indicated by the Midterm Exam (UTS) scores obtained by grade 8 students. To obtain accurate data, the researcher conducted a document analysis of all students' UTS scores. The results of this quantitative analysis are then presented in Table 2, which shows the average score of each class.

Table 2. Average Test Scores of 8th Grade Students

Class	Mid-term Test Score	Description
VIII A	45	Low
VIII B	60	Enough
VIII C	60	Enough
VIII D	45	Low
VIII E	55	Low
VIII F	70	Enough
VIII G	60	Enough
VIII H	55	Low
VIII I	75	Enough
VIII J	45	Low

Data in Table 2, it is clear that the overall average student score is still below the expected standard. From the results of data analysis, it is found that the knowledge value of students is in the low category with an average value of 56. This shows that the knowledge value of students, especially in science subjects, is still low. From the results of the analysis, it can be seen that there is a gap between student learning achievements and predetermined learning objectives. This can be caused by several factors such as the lack of interest and motivation of students in learning science.

The second problem is found in the results of students' creative thinking and communication skills. The assessment was carried out when both classes were carrying out experimental activities using science books available at school. This assessment sheet consists of two, namely the creative thinking skills assessment sheet and the communication assessment sheet. First, the results of the analysis of creative thinking skills. This creative thinking assessment consists of four indicators. The four indicators are sparking many questions clearly (K1), having varied ideas (K2), being able to generate unique ideas for problem solutions (K3), and providing ideas to solve problems (K4). The results of the analysis of students' creative thinking skills can be seen in Figure 2.

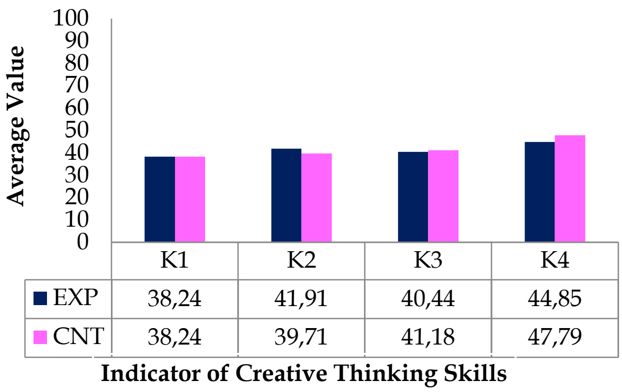


Figure 2. Initial analysis result for creative thinking skills

The data in Figure 2 shows the initial scores of students' creative thinking skills in the experimental and control classes. The results of the initial data analysis explained that the value of students' creative thinking skills in both sample classes was in the range of 38.24 to 47.79. The average value obtained was 41.36 for the experimental class and 73 for the control class. Based on the initial average scores in both sample classes, it shows that both sample classes have equally low creative thinking skills. Thus, efforts are needed to improve students' creative thinking skills.

Second, the results of the communication skills analysis. The assessment of communication skills consists of oral and written communication which is classified into seven indicators. The seven indicators are respect (K1), empathy (K2), can be heard (K3), oral clarity (K4), humble (K5), understandable (K6), and clarity of writing (K7). The results of the analysis of students' communication skills can be seen in Figure 3.

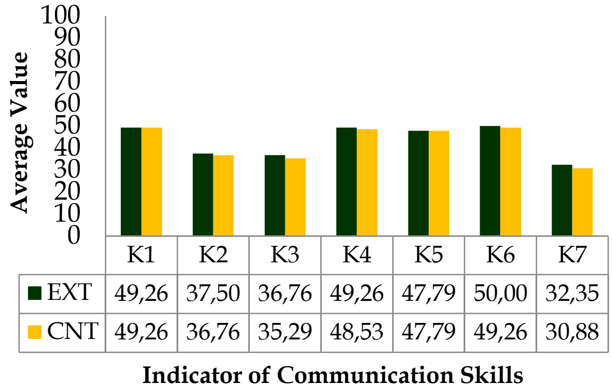


Figure 3. Preliminary analysis results for communication skills

The data in Figure 3 shows the initial scores of students' communication skills in the experimental and control classes. The results of the initial data analysis explained that the value of students' communication skills in both sample classes was in the range of 30.88 to 49.26. The average value obtained was 43.28 for the experimental class and 42.54 for the control class. Based on the initial average scores in both sample classes, it shows that both sample classes have equally low communication skills. So, efforts are needed to improve students' communication skills.

Based on the analysis of problems in learning, two problems were found. First, students' learning outcomes were low. Second, students' creative thinking and communication skills are low. The solution offered is to develop DTMIS-Blended PBL in science learning.

Validity Test Analysis Results

The validity test of DTMIS-Blended PBL consists of two. First, the results of the self-evaluation analysis conducted by oneself. This analysis aims to assess the feasibility of the product that has been developed and make product revisions. The results of the self-evaluation analysis can be explained in Table 3.

Tabel 3. Self Evaluation Results DTMIS-Blended PBL

Before Revision	After Revision
There are still typing errors	Typing errors have been corrected
There are still errors in writing symbols	Incorrect symbols have been corrected
There are still colors that do not contrast	Color errors have been changed to be more contrasting and more attractive

Table 3 presents data on the condition of DTMIS-Blended PBL before and after the self-evaluation process. The results of this comparison show that the DTMIS-Blended PBL has been significantly improved, becoming better than the previous version. The revisions made were crucial in addressing the errors identified during the self-evaluation. These corrections have improved the overall quality and accuracy of DTMIS-Blended PBL. After the self-evaluation and revision, the DTMIS-Blended PBL was then submitted to experts for a thorough validity assessment. This expert review will further validate the suitability of this DTMIS-Blended PBL for its intended purpose.

The results of the next validity test analysis are the validity of DTMIS-Blended PBL. The validity of DTMIS-Blended PBL has been done by five experts. The indicators assessed consisted of four indicators. The four indicators are material substance, learning design, visual communication display, and software utilization. The results of the validity test analysis according to this expert can be seen in Table 4.

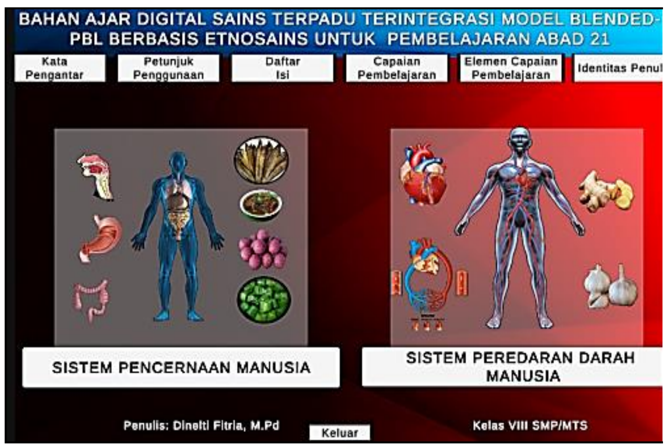
Table 4. Validity Results of DTMIS-Blended-PBL

Indicator	Aikens' V	Category
Material substance	0.85	Valid
Visual communication display	0.88	Valid
Learning design	0.83	Valid
Software utilization	0.90	Valid

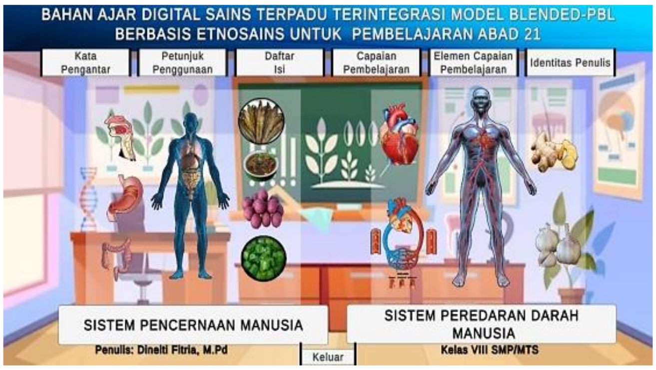
The data in Table 4 shows the results of the validity analysis of integrated science digital teaching materials integrated blended-PBL model. From the data it can be seen that all indicators of the validity assessment of integrated digital science teaching materials integrated blended-PBL model are in the valid category with a value range of 0.83 to 0.90. Each indicator previously had sub-indicators. First, in the material substance indicator, there is one sub indicator that has a lower value than the other sub indicators, namely “There is Ethnoscience in the circulatory system material”. This is because the integration of ethnoscience already exists but not as expected. Second, the visual communication display indicator, namely “Indicators of achievement of learning objectives in digital teaching materials are in accordance with the Learning Outcomes” has a low validity value than other sub-indicators. This is because the objectives to be achieved are still not clear. Indicators of learning design and software utilization are valid and feasible to use. The average of the overall validity test of integrated science digital teaching materials integrated blended-PBL model is 0.87 and can be categorized in the valid category. Thus, DTMIS-Blended PBL is valid and can be used in schools.

An in-depth evaluation of the digital teaching materials identified a number of weaknesses that need to be addressed. Based on constructive feedback from experts in related fields, several important aspects of the teaching materials require comprehensive revision. The suggestions and input from these validators became the main reference in making improvements to the digital teaching materials. The results of in-depth analysis of validator input have resulted in several significant changes to digital teaching materials. These changes include the cover, exercises and evaluation questions, materials, and integration of blended-PBL in teaching materials. The results of the revision based on suggestions from experts are as follows.

The first revision targeted the cover design of the teaching materials. Based on feedback from the validators, the cover background design was considered monotonous and less visually appealing. To increase the attractiveness of the cover, it is recommended to repeat the design elements on the background. The use of contrasting colors between text and background is also an important point in this revision. A more harmonious combination of visual elements is expected to give a fresher and more attractive impression to users of teaching materials. The changes made include adding a variety of visual elements to the background and selecting a more contrasting color combination. This cover design improvement is an effort to improve the aesthetic quality of teaching materials so that they are more attractive and effective in conveying learning materials. Thus, it is expected that the revised teaching materials can be more easily understood and remembered by students. The final revised cover design can be observed in Figure 4.



(a)



(b)

Figure 4. (a) Cover before revision; (b) Cover after revison

The second improvement relates to the improvement of exercises and evaluation questions in teaching materials. The improvements made are the focus of improvements to the teaching materials. Based on input from validators, the questions need to be adjusted with a more specific scoring rubric to measure the creativity and communicative aspects of students. Improvements to the exercises and evaluation questions have been made thoroughly. The questions have been revised to ensure their suitability with the new scoring rubric. A complete scoring rubric will help in providing more objective and constructive feedback to students. With better exercises and evaluation questions, students are expected to develop critical, creative, and communicative thinking skills more effectively. These improvements are a follow-up to the validators' suggestions. This shows the commitment of the development team to produce quality teaching materials and in accordance with predetermined standards.

Third, improving the material in teaching materials. From the suggestions given by the validator, it is stated that the material should be made varied, equipped with pictures and videos so that it is more interesting for students. The teaching materials have been revised with the addition of various types of media, such as images and videos. This aims to increase the attractiveness of the material for students and facilitate understanding of concepts. The images chosen have direct relevance to the topics discussed, so that they can strengthen students' understanding of the material. Proper visualization can help students imagine abstract concepts and connect them to the real world. In addition to images, educational videos are also integrated into the teaching materials. This audio-visual media can present information more dynamically and interactively, so that students are not easily bored in learning. The selection of videos is done carefully, ensuring that the content is appropriate for the students' cognitive level and supports the learning objectives. A quality video can be an effective tool for conveying complex concepts or providing examples of the application of material in everyday life. With these improvements, it is expected that teaching materials can be more effective in increasing students' learning motivation and achieving the learning objectives that have been set. Interesting and varied materials can create a more meaningful learning experience for students.

Last, related to the integration of blended-PBL in teaching materials. The validator stated that the integration of blended-PBL should be clearly visible in which parts are carried out online and in which parts are offline. Both parts have been revised. The online part is when they learn the material using videos, do work activities through online platforms, search for additional material via the internet, and posttest. While the offline part is an order to carry out joint discussion activities in class and listen to material explanations directly by the teacher in class. These improvements are intended to improve and perfect the teaching materials that have been developed, so that they are suitable for use. The results of these improvements can be used at a later stage by students.

Practicality Test Analysis Results

The practicality test of DTMIS-Blended PBL consists of three tests, namely one-to-one, small group, field test. The first practicality analysis result is the one-to-one stage. At this stage, digital teaching materials are used by three students who have different abilities, namely high, medium, and low. The instrument used is the learner's practicality sheet. The assessment of the practicality of digital teaching materials consists of three indicators. The three indicators are usable, easy to use, and appealing. The results of the analysis of the practicality of electronic teaching materials at the one-to-one stage can be seen in Figure 5.

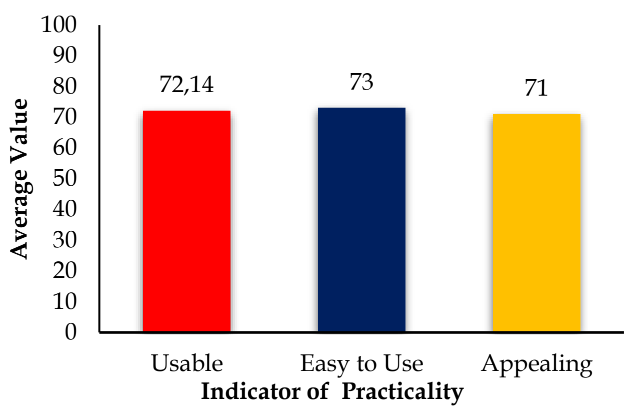


Figure 5. Practicality test results at the one-to-one stage

The data in Figure 5 shows the practicality value of DTMIS-Blended PBL at the one-to-one stage. The practicality value of teaching materials ranges from 71 to 73. The indicator of easy to use has the highest value of the others, 73, which is in the high category. This shows that the digital teaching materials developed are easy for students to use in learning science. The appealing indicator has the lowest value of the others which is 71. However, the appealing indicator is still classified as practical. The average practicality of digital teaching materials at this one-to-one stage is 72 and is in the high category. Thus, DTMIS-Blended PBL is practical and can be continued to the next stage.

The second practicality analysis result is the small group stage. At this stage, digital teaching materials are used by nine students who have three different abilities, namely high, medium, and low. The instrument used is the learner's practicality sheet. The assessment of the practicality of digital teaching materials consists of three indicators. The three indicators are usable, easy to use, and appealing. The results of the analysis of the practicality of electronic teaching materials at the small group stage can be seen in Figure 6.

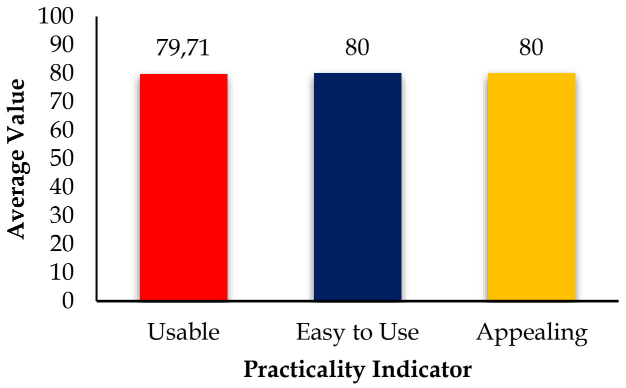


Figure 6. Practicality test results of small group stage

The data in Figure 6 shows the practicality value of integrated science digital teaching materials at the small group stage. The practicality value of teaching materials at this stage ranges from 79.71 to 80. The average practicality of digital teaching materials at this small group stage is 79.90 and is in the high category. Thus, DTMIS-Blended PBL is practical and can be continued to the next stage.

The third practicality analysis result is the field test stage. At this stage digital teaching materials are used by all students in the experimental class. The instrument used is the students' practicality sheet. Assessment of the practicality of digital teaching materials consists of three indicators. The three indicators are usable, easy to use, and appealing. The results of the analysis of the practicality of electronic teaching materials at the field test stage can be seen in Figure 7.

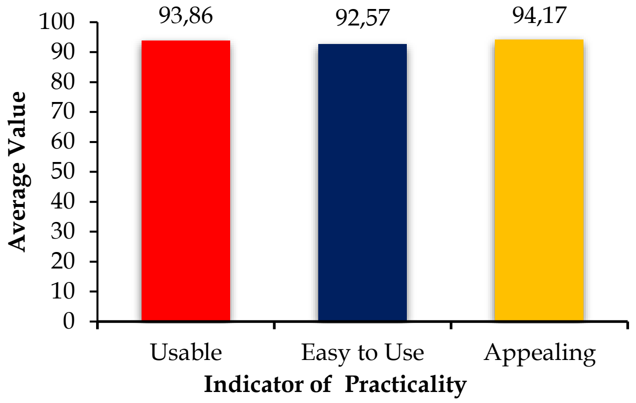


Figure 7. Results of the practicality test at the field test stage

The data in Figure 7 shows the practicality value of the integrated science digital teaching materials at the field test stage. The practicality value of teaching materials ranges from 92.57 to 94.17. The three indicators of the practicality of teaching materials have a very high average value of practicality. This indicates that the digital teaching materials developed can be used by students at any time, easy to use, and interesting. The average practicality of digital teaching materials at this field test stage is 93.53 and is in the very high category. Thus, DTMIS-Blended PBL is practically used by students in science learning.

Discussion

The first discussion, the results of the analysis showed that student learning outcomes, especially students' knowledge, were still low. This can be influenced by the lack of in-depth understanding related to the integrated science teaching method. This causes a lack of ability to teach science material effectively which will later affect student learning outcomes.

The second discussion, the results of the analysis showed that the students' creative thinking and communication skills were low. This can be caused by a lack of learning activities that can stimulate students to communicate and think creatively. The activity in question is a scientific activity that can support the active involvement of students so that they can train their thinking skills (Baysal et al., 2022; Ferty et al., 2019). Scientific activities can make students play an active role in learning (Husna et al., 2022; Martín-García et al., 2024). Scientific activities can be carried out with the support of the right learning resources such as teaching materials. This activity can be arranged using a learning model that can stimulate the skills possessed by students. In addition to being able to discuss in solving problems, students can also communicate the results well. In solving problems, students can also improve their creative thinking skills. So, this research is very necessary to improve students' 21st century skills, especially creative thinking and communication skills.

Before the validity test, the design of DTMIS-Blended PBL must be well developed. The three products developed are independently tested for feasibility first. At this stage, an inspection of the completeness and neatness of the products that have been developed is carried out. Based on the results of self-validation, it was found that the product developed had been made as attractive as possible. Minor mistakes such as the case.

Discussion regarding the feasibility of developing integrated digital science teaching materials The teaching materials can be considered feasible if they meet four indicators of feasibility These four indicators of feasibility are material substance, instructional design, visual communication display, and software utilization (Kemendiknas, 2010). In the assessment of material substance, the developed teaching material is considered appropriate if it contains the arrangement of material substance, accuracy of content, language used, and completeness of material (Nurhasanah et al., 2022; Sriwahyuni et al., 2019, Anista et al., 2022; Fitri & A, 2022). In the assessment of instructional design, teaching materials are considered appropriate if they contain real-life contexts that can facilitate learners in building understanding and enhancing their thinking and communication abilities (Kwangmuang et al., 2021). In the assessment of visual communication, instructional materials are considered suitable for use if the navigation within the instructional materials functions well and the layout of the instructional materials is also proportional (Nida et al., 2021). In the assessment of software utilization, the instructional materials developed must be original works and have utilized the latest software in their development (Mufit et al., 2023). Therefore, this integrated digital science teaching material is considered appropriate if it meets those four indicators.

The next discussioan is about the practicality of DTMIS-Blended PBL. First, the discussion on the practicality of one-to-one testing. Based on the analysis results, digital teaching materials are practical to use. They are considered practical because they are easy to use and can stimulate students' abilities. Second, the discussion on the practicality of small group testing. From the analysis results, it is known that the developed digital teaching materials are practical. These materials are considered practical because they can be used. In other words, the developed teaching materials can provide ease in learning, improve concept mastery, and ultimately achieve learning objectives (Triwulandari et al., 2022). Thus, digital teaching materials are practical to use and can be tested in one class.

The third, discussion of the practicality of the field test. The analysis results indicate that digital teaching materials are practical for use in science learning. Teaching materials are considered practical because they can be used anytime and anywhere, are easy to use, and are engaging. Practical teaching materials can be used in learning (Novia et al., 2023; Pandia et al., 2023; Gobel et al., 2023; Virijai & Asrizal, 2023; Yulyani et al., 2023). The attractiveness of digital teaching materials is assessed based on their appealing presentation, which includes animations, videos, and images (Sriwahyuni et al., 2019). Furthermore, digital teaching materials also contain content that can be easily mastered by students independently (Asrizal, 2020). Digital teaching materials also contain interconnected science content between Biology, Physics, and Chemistry, making learning more meaningful (Henne et al., 2023; Linda et al., 2021). Therefore, the use of integrated digital science teaching materials in science learning is practical for students.

Conclusion

Based on the research results, three conclusions can be presented. First, there are problems in learning, especially low student achievement and creative and communicative thinking skills. Efforts are needed to improve students' communication skills. Second, DTMIS-Blended PBL is valid with an average score of 0.87. This valid integrated digital science teaching material is considered suitable for use in the learning process. Third, DTMIS-Blended PBL is practical with an average score of 93.53. Practical integrated digital science teaching materials can be used in the learning process. Therefore, the developed DTMIS-Blended PBL is valid and practical for use in science education and is worthy of further research.

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Author Contributions

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Conflicts of Interest
The authors declare no conflict of interest.

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