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Development of Interactive E-Book Based on Project Based Learning-STEM to Improve Creative Thinking and Collaboration Skill in Vocational Schools

Sayyid Muhamad Alwi[1*], Eges Triwahyuni[1], Hariyanto[1]

[1]Department of Educational Technology, Postgraduate, Universitas PGRI Argopuro Jember, Jember, Indonesia.

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Corresponding Author:
Sayyid Muhamad Alwi
alwi.alnara@gmail.com

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Abstract: The participation of SMK students is driven by employment goals and in response to market constraints and personal challenges, hence the need for flexibility in vocational training. The purpose of preparing the research is the development of interactive e-books, product feasibility, and the effectiveness of using Interactive E-books in class X DPIB at SMKN 2 Jember. This research is a Research and Development (R&D), in the form of an ADDIE model approach, which consists of five levels, namely analysis, design, development, implementation, and evaluation. The results of the validation assessment show the percentage of the feasibility of the media component of 94.67% and the material component of 95.56%, can be categorized as "Very Valid". The results of product feasibility tested on students, have a feasibility percentage of 99.01%, indicating that the Interactive E-book is "Very Feasible". The results of the analysis test on the pretest and post-test scores showed an average increase of 36.16 with an N-Gain of 86.71 in the high category. These results show that X DPIB SMK students are better when applying media in the form of Project Based Learning-STEM interactive e-books and can improve creative thinking and collaboration skills.

Keywords: Collaboration skill; Creative thinking; Interactive e-books; Project-based learning; Stake out measurement; STEM

Introduction

The future need for labours qualifications is changing very dynamically along with technological advances (Mahfud et al., 2024). Vocational education aims to develop competencies, skills, attitudes, understanding, and even work behavior that are needed by graduates to enter the productive industrial world (Purwaningsih & Yoto, 2022). This is because the characteristics of the business world will also qualify the workforce, which is the need of the industry to develop and change rapidly, so skills must be supported academically as well (Rohmanudin et al., 2022).

The participation of vocational students is driven by occupational goals and in response to market constraints and personal challenges, hence the need for flexibility in vocational training (Ye & Nylander, 2024). To remain relevant to the world of work, SMK graduates must learn and adapt quickly (Mahfud et al., 2024). Secondly, learning patterns in vocational schools tend to be individualized, de-emphasizing collaboration. Because collaboration will allow for better decision-making than individuals (Atun & Latupeirisa, 2021). Third, teaching materials that are in line with industry demands are not yet available.

In facing the challenges of a very progressive industrial development, the role of vocational education in SMK must follow suit. In fact, there is a gap between the needs of the industry and the pattern of learning in vocational schools. Observations made at SMKN 2

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Jember show that teachers do not teach materials that follow industry needs. Also, the assignment pattern of SMK students tends to be individual. So, it is necessary to build a curriculum that is in line with the industry and accommodates the form of learning patterns that are in line with work preparation. One form is to apply collaboration in work.

The fast-paced development of the industrialized world has increased global competitiveness, the change of the economy to an industrialized one (Ichwanto et al., 2021). Including, the landscape of vocational education is changing fundamentally, as the influence of technology is transforming industries rapidly (Ubihatun et al., 2024). SMK graduates should have a variety of skills that can be applied to a variety of professions, positions, and career stages (Mahfud et al., 2024). Additionally, vocational education is also directed towards meeting a dynamic structure to respond to technological knowledge, production methods, and industry needs (Dahil et al., 2015).

One form of structure to balance industry standards is the Indonesian National Work Competency Standard (SKKNI). The suitability of the curriculum with SKKNI requirements is expected to produce graduates who have relevant competencies and are ready to contribute to the world of work (Destyawan et al., 2023). SKKNI or often referred to as the Indonesian National Work Competency Standards can serve as a national model for technical and professional education (Baumann et al., 2014). This standard was developed through discussions with the relevant industry to ensure its relevance to the needs of the workforce (Bahri et al., 2024).

Table 1. Structure of interactive e-book materials in the field of stakeout measurement

Material	Material Description
Material 1: Introduction	Definition of land measurement, Definition of stake out, Understand the drawing of stake out implementation, Determine the stake out measurement method, and Apply standard K3 procedures.
Material 2: Stake Out Measurement Setup	Prepare stake out measurement equipment, Setting Bench Marking (BM) points for stake out measurement, Calculating data for stake out measurements, Marking stake out measurements that have been completed in the form of dots, and Carry out recording in the form.
Material 3: Stake Out Measurement Implementation	Carry out horizontal direction measurement according to evaluation data, and Carry out vertical direction measurement according to evaluation data.

The need for synchronization between the curriculum in SMK and SKKNI to create efficiency (Yasdin et al., 2023). So, the research seeks to build teaching materials that are relevant to competencies in the labour market. The material whose relevance is built is land measurement science. This material is synchronized with the SKKNI in the field of land surveyor (SKKNI Juru Ukur, 2015). That will focus on the unit of competency Performing Stake Out Measurement. Then the results of material synchronization are obtained as in Table 1.

The results of the synchronization of stakeout measurement materials will be incorporated into relevant teaching materials for vocational schools, one of which is an interactive e-book. The use of e-books employs technology to convey information quickly through sound, graphics, images, animations, and videos, also offering richer content compared to conventional books (Jamil et al., 2024). The implementation of interactive e-books is relevant across various levels of education, including vocational schools, due to the need for practicality, speed, and ease of access (Rahim et al., 2020). It is also reinforced that the review of Technology Enhancing Learning can improve interaction among learners, enhance perceived satisfaction, and increase speed (Keedle et al., 2024). Development of an e-book based on Project Based Learning-STEM. Through Project Based Learning can replace innovative teaching approaches, to eliminate traditional methods (Fajrina et al., 2024). In addition, the PjBL model can provide benefits for students in making the right decisions in its application (Aswan et al., 2024).

The PjBL approach which also offers multi-disciplinary learning is aligned with STEM (Science Technology Engineering Mathematic). Students are encouraged to participate by exploring meaningful learning through understanding topics and elaborating with project activities through the PjBL-STEM approach (Prajoko et al., 2023). STEM disciplines combined with PjBL can emphasize the process of systematically designing student tasks to perform problem solving (Putri et al., 2021).

The application of PjBL-STEM integrates the indicators of each approach. The indicators of PjBL will be a reference in developing the interactive e-book. The indicators of PjBL can be stated as follows: elaborate the project theme by discussing, teachers encourage students to be free in choosing parts of their learning group, the teacher must provide facilities for students to explore equipment and references that are tangible in the support of tasks about the project, conduct in-depth guidance to students in project activities, and the teacher seeks to actively determine technical instructions in the description of the report on the results of project activities (Amri et al., 2020).

Second, the STEM approach. In secondary education, PjBL in the context of STEM requires

integration between various disciplines and is relevant to technology-based vocational schools (Santos et al., 2023). STEM-based learning strongly supports learning that emphasizes holistic and interactive outcomes and plays a role in solving real problems in learning (Muzakiah et al., 2024). Also, STEM learning can effectively address improving science literacy with the integration of technology in learning (Pane et al., 2024). It is also corroborated by the opinion that STEM education can be effective in getting graduates who are able to apply concepts to the real world for problem solving, not just limited to knowledge of science, math and technology concepts (Nursafitri & Ansori, 2024). The STEM indicators on which the interactive e-book is based are as follows: engineering of design process, science or mathematic integration, advanced manufacturing technology, and collaborative of group work (Gale et al., 2020).

The development of interactive e-books based on PjBL-STEM will be tested on its effectiveness with two variables, namely creative thinking, and collaboration skills. First, creative thinking, because it is an important skill that can be a provision for global competitiveness for businesses and countries (Kuo et al., 2024). Creative thinking is the process of synthesizing past knowledge and experiences to generate new ideas, concepts, and solutions (Wang et al., 2024). Because students' creativity can be observed from their personalities when exploring the objects around them (Mughni & Sari, 2024). The indicators of creative thinking are as follows: flexibility, fluency, elaboration, originality, and imagination (Suryawan et al., 2024).

Second, the collaboration skill variable, because of the demands of the world of work that prioritize cooperation. Collaboration skills are part of the important skills needed by business and industry in the 21st century apart from communication, creativity, critical thinking, and problem solving (Andersen & Rustad, 2022). Collaboration can have a positive effect on learning, the learning environment is more innovative, students can absorb the material easily, and provide opportunities for students to share ideas to hone skills, namely interpersonal, communication, teamwork, and leadership (Adhiyah & Pertiwi, 2024). The indicators of Collaboration Skill are as follows: contribution to colleagues, time management in activities, problem solving process, cooperate with others, apply the method of inquiry, and incorporation (Wafom et al., 2023).

The novelty of this research lies in the focus on the development of PjBL-STEM-based interactive ebook teaching materials with material synchronization with SKKNI. In addition, this interactive ebook teaching material seeks the influence of creative thinking skills and collaboration, where the discussion of PjBL-STEM-based vocational teaching materials has not been maximally explored in vocational schools in Indonesia. At the same time, the Project Based Learning strategy can complement the STEM approach, because project-based learning is known to be effective in facilitating knowledge acquisition and retention in the development of real-world knowledge (Yuliawati et al., 2024).

Based on the description in the introduction, a study was made entitled "Development of Interactive E-books Based on Project Based Learning-STEM to Improve Creative Thinking and Collaboration Skills in Vocational Schools".

Method

This research is a type of research and development or development study. R&D research is a research method for developing and testing the resulting products that will later be developed in the field of Education (Bennett et al., 1984). There are several research models that can be used as references for the basis of development research. This research uses the ADDIE model, which stands for Analyze, Design, Develop, Implement, and Evaluate (Branch, 2010). Therefore, the development research procedure is outlined in Figure 1.

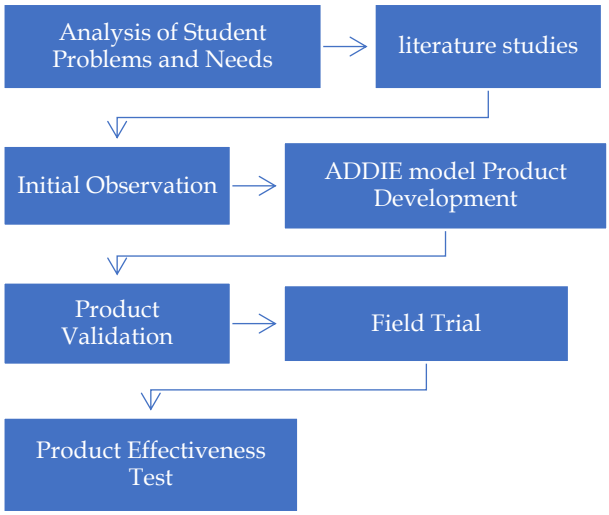

Figure 1. Research and development procedures

In the development procedure, several stages are carried out. First, Analyze, which means analyzing the gaps that occur in the research. The steps taken in the analysis are implementing the gap in the research, determining the objectives for product development in the research, confirming with students to see the gap directly, identifying the resources needed, designing or estimating the costs required for product development, and preparing a project management plan for teaching

materials (Branch, 2010). Next, determining the instructional objectives of the development research and identifying the resources needed for the research. Finally, it is to develop a project management plan for the teaching materials, namely an interactive e-book.

Second, Design, which involves verifying performance and testing according to the development method. In its implementation, according to Branch (2010), The design phase consists of several parts, namely: conducting inventory tasks, formulating product development goals, formulating relevant testing methods, and calculating Return on Investment. The Design step is carried out by designing an interactive e-book model of Project Based Learning with a STEM approach. At this stage, the characteristics of the interactive e-book and product development instruments (teaching material syllabus synchronized with SKKNI, pre-test, post-test, and student response questionnaires) are prepared.

The three stages of Develop are to produce and validate resource needs. The following are some stages of development, namely: producing content, developing & elaborating supporting media, developing user instructions for students, developing user instructions for teachers, conducting formative revisions, and implementing product testing (Branch, 2010). Development of product drafts, implementing interactive eBooks on research objects and instruments that have already been validated.

The goal of the development stage is to produce a revised draft of the interactive E-book based on feedback and evaluations from experts as well as data obtained through field trials. Expert appraisal includes content validity, which consists of the content aspect of the interactive E-book (whether it aligns with the subject matter and the objectives to be measured) and the media aspect (whether it adheres to the proper and appropriate use of media). Developmental testing is conducted to obtain direct feedback from the field on the assembled interactive E-Books.

The four stages of Implementation, preparing the learning environment, and involving students in product testing (Branch, 2010). Field trials are conducted to test the effectiveness or impact of the developed learning model. This stage is the stage of using the developed learning devices on a larger scale, for example, in other classes at the same level.

Final step. Evaluate, which means assessing the instructional quality of the process and product, both before and after implementation (Branch, 2010). The result of the implementation, when product revisions are necessary, this stage involves product improvements. The aim is to achieve results that align with expert recommendations. The type of evaluation uses a summative test in that subject. Jointly involving teachers and researchers to observe progress in the use of media. It can take the form of score analysis after conducting product tests.

The subjects of this research are in the Vocational Competency of Building Modeling and Information Design (DPIB). The research population taken is the X DPIB1, X DPIB2, and X DPIB3 classes at SMKN 2 Jember for the 2024/2025 academic year. The trial sample was conducted on students of class X DPIB 1 SMKN 2 Jember. The trial subjects were selected based on the alignment between the problems and the solutions offered in this development research.

Data analysis is conducted after the entire data collection process of the research is completed. Data analysis is carried out by organizing the data, elaborating on the data, categorizing the data, so that conclusions can be drawn from the obtained data (Sugiyono, 2019). In this study, two types of data were used, namely qualitative and quantitative. First, qualitative data analysis is a data processing technique where is combining and to analysis information from the data obtained, such as criticism, suggestions from the questionnaire. Qualitative data will be converted into systematic and structured data. Second, quantitative data analysis is a way of processing data based on information about research subjects that is systematically arranged in the form of percentages and numbers.

Data on the validity of learning devices is obtained using a validation sheet containing aspects and assessment indicators, which are then filled in by expert validators to assess the quality of the learning devices being developed (Arikunto, 2017). The validity tested in this research is content validity and media validity. The validity test functions to determine whether an instrument can be used to accurately measure the aspect that is to be measured (Arikunto, 2017).

The validity test conducted by the validator is also analyzed to obtain data on whether the developed learning device is valid or not (Sugiyono, 2019). The validity test conducted in this research aims to determine the quality of media and materials from the learning devices by two validators. The validators provide assessments on the validation sheets that have been prepared for each aspect. The assessment results that have been provided are referred to as validation data.

According to Sugiyono (2019), an instrument is said to be valid if it can be used to measure what it is supposed to measure. Meanwhile, the reliability test of the instrument is a test to ensure that the instrument has consistency, so it can be used accurately. For test items, validity and reliability tests are conducted using SPSS. Learning devices are considered valid if they have a significance value (Sig. 2-tailed) less than 0.05 and are

considered reliable if they have an alpha value (Alpha Cronbach) greater than 0.6.

First, the analysis of the interactive e-book validation results. In this analysis, there are several validity steps for the developed interactive e-book. The analysis calculation uses a Likert scale, with a range of 1-5. Continued by calculating the percentage of the total score of the answers using the following formula:

$$\text{Validity} = \frac{\text{Total answer score}}{\text{Maximum score}} \times 100\% \quad (1)$$

The results obtained from the media and material validation tests are then interpreted according to Table 2.

Table 2. Criteria for validity test of interactive e-book

Value	Interpretation
81–100	Perfectly Valid
61–80	Valid
41–60	Fairly Valid
21–40	Less Valid
0–20	Not Valid

Instruments or learning devices can be used in research if these instruments meet the criteria of being valid or highly valid (Arikunto, 2017). Although the instruments meet the validity criteria, if revisions are still needed according to the validator's suggestions, then revisions will be made to those instruments.

The results of the validator's revision, the developed e-books product to determine the feasibility of the product. The revised interactive e-books will be implemented for teachers and students. The analysis of the product feasibility results of the interactive e-books is data that shows the feasibility of the interactive e-book that has been developed in the learning process. The steps in the data analysis related to the feasibility of the interactive e-book involve summing the scores from all meetings and calculating the percentage score. The value of product feasibility also uses a Likert scale. The calculation of the product feasibility percentage is as follows.

$$\text{Feasibility} = \frac{\text{Total answer score}}{\text{Maximum score}} \times 100\% \quad (2)$$

The results obtained from the feasibility test are then interpreted in Table 3.

Table 3. Interactive e-book product feasibility test criteria

Value	Interpretation
81–100	Perfectly Valid
61–80	Valid
41–60	Fairly Valid
21–40	Less Valid
0–20	Not Valid

Next, the analysis of the effectiveness level of the development product. This analysis uses the N-Gain test approach. This analysis aims to measure the process of improvement (gain) in learning achievement or understanding after the implementation of a learning intervention, whether through the application of a specific model, method, or media (Hake, 1998). The development of the interactive E-book product was tested for its effectiveness on Creative Thinking and Collaboration Skill. The result for the N-Gain test is as follows:

$$< g >= \frac{87.69 - 45.00}{100.00 - 45.00}$$

Note:

$< g >$ = N-Gain

The results of the N-Gain calculation were then categorized according to the criteria in Table 4 (Hake, 1998).

Table 4. N-Gain score criteria

Value	Interpretation
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$g < 0.30$	Low

The results of the N-Gain analysis are divided into three categories. The product is declared effective if the calculation results of the n-gain formula indicate a high value. The data obtained from the administration of questionnaires/surveys is analyzed by determining the number of students who provide positive and negative responses for each category asked in the survey. Positive responses mean that students support, feel happy, and are interested in the components and learning activities through the application of the model. Negative responses mean the opposite. To determine the achievement of learning objectives based on student responses, if the number of students giving positive responses is greater than or equal to 80% of the total subjects studied. Finally, data analysis was conducted, including normality tests to determine data distribution, t-tests to compare pretest and posttest results, and N-Gain tests aimed at measuring the effectiveness of the Interactive E-book in enhancing Creative Thinking and Collaboration Skills.

Result and Discussion

Development of Project Based Learning-STEM Based Interactive E-books

In the development of this interactive eBooks, the researchers used the ADDIE development model applied to the X DPIB 1 class at SMKN 2 Jember. This development model consists of five stages: Analyze,

Design, Development, Implementation, and Evaluation. First, in the analyze stage, the researcher conducted observations of the learning activities in class X DPIB 1 SMKN 2 Jember, interviews with colleagues, and analyzed the alignment of the vocational school curriculum with job market demands.

The analysis results showed that there was a mismatch between the students' learning process in class because the learning materials still adhered to government standards and had not yet followed industry demands. The learning process is still focused on the individual level, with no collaboration yet. Therefore, the development of teaching materials that meet job demands is highly needed by vocational schools. Teaching materials can also accommodate learning that emphasizes collaboration, as job demands require collaboration with colleagues.

Second, the design stage involves creating the teaching materials, specifically an interactive e-book. First, synchronize the material with the relevant SKKNI on the topic of Conducting Stake Out Measurements. The material was divided into three chapters. In the development strategy formulation stage, the Project Based Learning-STEM model was used. The integration will result in an interactive e-book that is relevant to vocational high school students.

Third, the Develop stage. In this stage, we create the content for the interactive e-book. Starting with creating a concept map for each chapter on the topic of Conducting Stake Out Measurements.

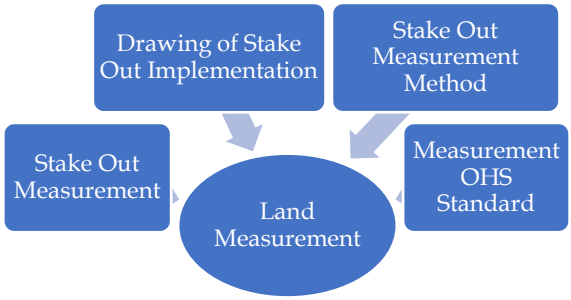

Figure 2. Concept map of the material

The next step is to create comprehensive content for the interactive e-book. Supporting media such as graphics and educational videos are also included in the interactive e-book. Then, it is followed by creating guides for students and teachers. Ended with product testing to be validated by subject matter and media experts.

Fourth, the Implementation stage. The stage of preparing the learning environment for limited product trials. The product trials are limited to 10 students in the field.

Figure 3. Interactive e-book material content

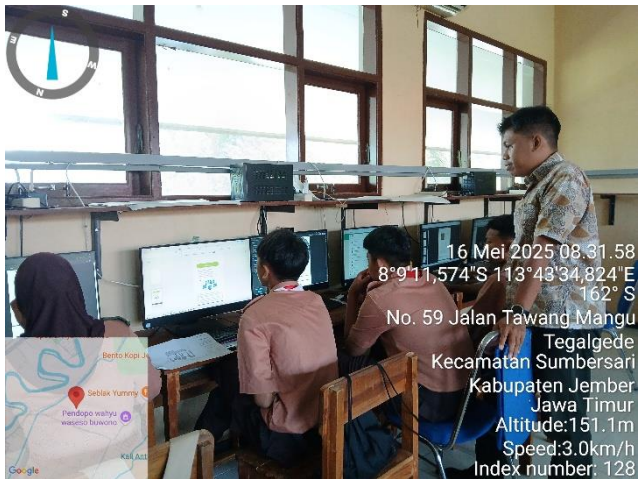

Figure 4. Product trial

Finally, the Evaluate stage. This stage assesses the results of the product validation that has been developed. The assessment results from media and material experts are summarized to obtain the outcome. The next step is to write the research results on the product that has been validated by the experts. The feasibility results of the interactive e-book product by two experts for each media and material. Here are the results of the product validation by media experts, which can be seen in Table 5.

Table 5. Media expert validation results

Aspect	Score
Cover Design	23
Content Design	48
Score Acquisition	71
Percentage (%)	94.67

The validation results from media experts show a score of 94.67%, which means "very valid." The interactive e-book media, based on the suggestions and input from media experts, includes several recommendations related to product development, as shown in Table 6.

Table 6. Media expert suggestion results

Description Feedback
The cover design gives a glimpse into the content of the book without giving away important information.
Avoid too much text or design elements that can be distracting

As for the media expert's input, the researcher made product revisions. The first is related to the cover design, which does not provide enough figures related to the material, presented in Figure 5.

Figure 5. Cover design revision

Second, is the result of validation by material experts, the results of product validation by material experts obtained a score of 95.56% with the interpretation of "Very Feasible". The conclusion that the interactive e-book product is very valid from the material expert is presented in Table 7.

Table 7. Material expert suggestion results

Aspect	Score
Suitability of learning media with Competency Outcomes	19
Suitability of student activity steps with material on learning media	14
Suitability Summary of material with learning media	14
Score Acquisition	43
Percentage (%)	95.56

Based on the suggestions and input from the material experts, there are several inputs related to product development, as in Table 8.

Table 8. Results of material expert suggestions

Description Feedback
The e-book has presented material that is relevant to the learning needs of SMK and synchronized with SKKNI. So that it really helps bridge the needs of schools and industry. Expanded with case studies that match real conditions in the field will be more complex.

Regarding the input from the subject matter expert, the researcher revised the product. First, concerning the case study in the e-book, which lacked illustrations related to the material, a revision was presented in Figure 5.

Studi Kasus

Peralatan dan bahan yang harus dipersiapkan:

1. Theodolite digital
2. Statif
3. Buku Catatan
4. Alat tulis

Cara kerja:

1. Mendiskusikan proyek yang diberikan oleh guru pengajar, yaitu pengukuran ulang bengkel Bangunan SMKN 2 Jember".
2. Membuat kelompok berdasarkan kesepakatan bersama antara guru dengan siswa.
3. Mengerjakan tugas proyek sesuai arahan guru, yaitu menyiapkan site plan SMKN 2 Jember sebagai dasar pengukuran ulang
4. Guru membimbing siswa dalam pengukuran bengkel bangunan.
5. Tiap kelompok mempresentasikan hasil pekerjaan di depan kelas.

Figure 6. Product revision with case study

The results of the developed product were tested to determine its feasibility. The total feasibility score percentage from the teachers indicates that it is very suitable to be tested on students. Based on the questionnaire results outlined in Table 9.

Table 9. Student testing

Respondents	Score (%)	Interpretation
Students	99.01	Very Feasibility

Responses from students indicate a feasibility level of 99.01%. Therefore, based on these responses, it can be

concluded that the media in the form of an interactive e-book is highly suitable for implementation in the subject of Land Surveying at vocational schools. This is in line with previous research which stated that students in the experimental class using a mathematics e-book have better mathematical thinking skills than the control class (Wijaya et al., 2022). Other results also support that the use of e-books has more strategies for completing tasks (Li et al., 2020).

Level of Effectiveness of Interactive E-book on Creative Thinking and Collaboration Skill

The final part of the ADDIE development model is Evaluation. This stage aims to measure the effectiveness of the developed interactive e-book. Based on the development results, the interactive e-book shows results without revisions. This aligns with the expectation that the final product can enhance the effectiveness of the material on Conducting Stake Out Measurements. The effectiveness of the product is measured by two things. First, pre-test and post-test measurements were conducted in the X DPIB1 class at SMKN 2 Jember. The initial stage is to test the initial abilities with a pre-test on 30 students with 15 multiple-choice questions. After testing the media in the form of an interactive e-book, a post-test was conducted on the students. Thus, pre-test and post-test results will be obtained as per Table 10.

Table 10. Pre-test and post-test result

Description	Pre-test	Post-test
Average	45.00	87.69
High Score	67	84
Lowest Rate	37	72
Number of Completed Student	2	28
Learning Completeness (%)	5.56	98

The assessment results in the pre-test and post-test show a significant comparison, as shown in Table 10. The score obtained from the pre-test was 45.00, while the post-test score increased to 87.69. Therefore, when compared, there is a difference of 36.16. At the pre-test stage, no students were able to achieve learning completeness, with a percentage of 5.56%. However, at the post-test stage, a learning completeness percentage of 98% was achieved. This data can be concluded that the developed product is effective in improving learning comprehension, as evidenced by the significant difference between before using the interactive e-book and after applying it to the material on Performing Stake Out Measurements. The results are reinforced that the e-book method has proven to help motivate students to achieve post-test scores through external motivation (Shatat et al., 2017). It is also supported that students experience an improvement in nursing practice performance after completing the program (Muzakiah et al., 2024).

To ensure that the tested data is normal, a normality test was conducted using Shapiro Wilk. The results of the pretest and posttest normality tests can be seen in Table 11.

Table 11. Normality test

Parameters	Shapiro Wilk	
	N	Sig.
MoCA-Ina pretest	30	0.068
MoCA-Ina pretest	30	0.132

Based on Table 11, the results of the pretest normality test conducted using the SPSS application show sig = 0.068. While the normality test results for post-test scores show sig = 0.132. If the significance value is > 0.050, the normality test criteria are considered normal.

Furthermore, a paired T test was conducted to determine the difference in the mean scores of the pretest and post-test. The purpose of this T test is to determine the significance level of the difference in the average student scores on the pretest and post-test.

Table 12. Paired T test

Result	Paired T Test	
	N	Sig. (2-tailed)
MoCA-Ina pre-test post-test	30	< 0.001

Based on Table 12 for the paired T-test, it shows a significant value of 0.000 (less than 0.005), indicating a significant difference between the pre-test and post-test results. These results indicate that the use of interactive e-books can enhance creative thinking and collaboration skills.

After the data testing has shown a normal distribution, an N-Gain test can be conducted. The purpose of the N-Gain test is to determine whether the scores obtained from the pretest and posttest can experience an average change (Hake, 1998). The data shows an average improvement if the N-Gain value criteria are > 0.3 for the moderate criterion and > 0.7 for the high criterion.

Table 13. N-Gain test

Result	N	Interpretation
Score of N-Gain	30	86.71

The N-Gain test results obtained a score of 86.71 in the very effective category. Therefore, it can be concluded that the development of interactive e-books based on Project Based Learning-STEM can enhance creative thinking and collaboration skills. The results of this study are also supported by several relevant studies.

First, it can be concluded that the development of interactive e-books can enhance creative thinking. In line with the opinion that project-based learning can improve creative thinking skills because students can participate in the learning process and play a role in developing their skills (Rea et al., 2024). This will provide breakthroughs and creativity for teachers to create teaching materials that are aligned with the use of mod as eBooks (Yani & Rosana, 2024). Creativity is also developed in PjBL-STEM for local contexts in learning, such as skills in the vocational high school domain (Utari et al., 2024). Because, with creativity can solve a variety of solutions or implement strategies in problem solving (Solaiman et al., 2024). Additionally, the selection of materials by collaborating with mathematics can enhance communication skills, problem-solving, creative thinking, and self-confidence (Wijaya et al., 2021).

Second, it was found that the use of interactive e-books can improve collaboration skills. Collaboration skills are skills to work effectively together, to build respect for team members of various backgrounds, to practice fluency and build willingness for the achievement of common goals (Beskara, 2024). Collaborative approach where there is social interaction between students in the classroom, aiming to achieve a common goal while respecting the contribution of each team member as a whole (Afrahamiryano et al., 2022). In addition, through collaborative learning, students can gain interaction or communication between students in the classroom, teaching materials, and teachers (Priyambodo et al., 2021). Because collaboration teaches students to be tolerant in solving problems (Fitri et al., 2024).

Conclusion

The results of this study indicate that the learning outcomes of X DPIB students in the subject of land measurement, specifically the stake out measurement material at SMKN 2 Jember, can be improved using Interactive E-books Based on Project Based Learning-STEM. The validation assessment results show a media component feasibility percentage of 94.67% and a material component validation percentage of 95.56%, categorizing it as "Very Valid." The product feasibility results tested on students show a feasibility percentage of 99.01%, indicating that the Interactive E-book is "Very Feasible." The analysis of pretest and posttest scores shows an average improvement of 36.16 with an N-Gain of 86.71, categorized as high category. This shows that the X DPIB vocational high school students perform better when using interactive Project Based Learning-STEM e-books as media, and it can enhance their creative thinking and collaboration skills.

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Author Contributions

Main author and article researcher, S.M.A.: collected information, created instruments to measure needs and responses, conducted validation assessments by subject matter experts and media experts, created evaluations, developed and tested the research product, data processing and initial article writing; research and writing of the second article, E.T. & H: conducted validation of the instruments and initial product design before submission to media and subject matter expert validators, supervising lecturers who guided and mentored the first author.

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Conflicts of Interest

The authors declare no conflicts of interest.

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