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ORIGINAL

Development of an Android-assisted STEAM-based Project Based Learning Model in Informatics Subjects at Vocational High Schools

Desarrollo de un modelo de aprendizaje basado en proyectos STEAM asistido por Android en asignaturas de informática en institutos de formación profesional

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ABSTRACT

This research aims to develop a STEAM-based Project-Based Learning (PjBL) model (Science, Technology, Engineering, Arts, and Mathematics) assisted by Android in Informatics subjects at SMK. This model was developed using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) approach to ensure its effectiveness and usefulness in improving student competence. With the integration of technology and a project-based approach, this model is expected to improve students' skills in problem solving, creative thinking, technical skills, and soft skills. 21st-century learning demands a learning model that is able to develop student competencies, especially in the aspects of critical thinking, creativity, communication, and collaboration (4C). The challenges of the industrial revolution 4.0 also require vocational education, especially in SMK, to produce graduates who are work-ready and able to adapt to technological developments. However, the low absorption rate of SMK graduates in the industrial world indicates a competency gap that must be addressed. Therefore, an innovative learning model is needed that can integrate 21st-century skills with industry needs. The results of this study are developing a STEAM-based project-based learning model. It has validity, practicality, and effectiveness that has been tested so that it is feasible to use in informatics subjects in vocational schools. The implications of this research can improve student learning outcomes in terms of cognitive, affective, psychomotor, and improve student soft skills. Thus, this learning model can be an effective alternative in supporting Informatics learning in SMK to face the challenges of the digital era and industrial revolution 4.0.

Keywords: 4C Soft Skills; 21st Century; ADDIE; Android; Industrial Revolution 4.0; Project-Based Learning; SMK; STEAM.

RESUMEN

Esta investigación tiene como objetivo desarrollar un modelo de aprendizaje basado en proyectos (PjBL) basado en STEAM (ciencia, tecnología, ingeniería, artes y matemáticas) asistido por Android en las asignaturas de informática en SMK. Este modelo se desarrolló utilizando el enfoque ADDIE (análisis, diseño, desarrollo, implementación y evaluación) para garantizar su eficacia y utilidad en la mejora de la competencia de los estudiantes. Con la integración de la tecnología y un enfoque basado en proyectos, se espera que este modelo mejore las habilidades de los alumnos en la resolución de problemas, el pensamiento creativo, las habilidades técnicas y las habilidades sociales. El aprendizaje del siglo XXI exige un modelo de aprendizaje capaz de desarrollar las competencias de los alumnos, especialmente en los aspectos del pensamiento crítico, la creatividad, la comunicación y la colaboración (4C). Los retos de la revolución industrial 4.0 también exigen que la formación profesional, especialmente en las SMK, forme a graduados preparados para el mundo laboral y capaces de adaptarse a los avances tecnológicos. Sin embargo, la baja tasa de absorción de los graduados de las SMK en el mundo industrial indica una brecha de competencias que debe abordarse. Por lo tanto, se necesita un modelo de aprendizaje innovador que pueda integrar las habilidades del siglo XXI con las necesidades de la industria. Los resultados de este estudio son el desarrollo de un modelo de aprendizaje basado en proyectos STEAM. Este modelo tiene validez, practicidad y eficacia, y ha sido probado para que sea viable su uso en asignaturas de informática en escuelas de formación profesional. Las implicaciones de esta investigación pueden mejorar los resultados del aprendizaje de los alumnos en términos cognitivos, afectivos y psicomotores, así como mejorar las habilidades sociales de los alumnos. Por lo tanto, este modelo de aprendizaje puede ser una alternativa eficaz para apoyar el aprendizaje de la informática en las SMK para hacer frente a los retos de la era digital y la revolución industrial 4.0.

Palabras clave: Habilidades Sociales 4C; Siglo XXI; ADDIE; Android; Revolución Industrial 4.0; Aprendizaje Basado en Proyectos; SMK; STEAM.

INTRODUCTION

The Industrial Revolution 4.0 has significantly changed the education landscape by introducing advanced technologies such as artificial intelligence (AI), internet of things (IoT), big data and cloud computing into the learning process. These developments have created new opportunities and challenges that must be addressed in creating an education system that is relevant to the needs of the 21st century. According to Wadhwa et al.[1], the Industrial Revolution 4.0 requires education to focus on developing 21st century skills, such as critical thinking, creativity, collaboration, and digital literacy.

The development of 21st-century learning marks a paradigm shift in education, emphasizing the development of 21st-century skills essential for student success in the developmental era of the Industrial Revolution 4.0. 21st-century education emphasizes technology integration, creativity, collaboration, problem solving, and critical thinking skills. According to Zhao[2], 21st-century education aims to produce individuals who are able to adapt quickly to change, solve complex problems, and contribute positively in a connected global society.

One important aspect of 21st century learning development is the use of technology in education. Technology has enabled the creation of adaptive and online-based learning models, such as distance learning and e-learning. According to Johnson et al.[3], technology plays an important role in facilitating access to education for all individuals, creating personalized and affordable learning opportunities.

21st-century education emphasizes the importance of project-based learning (PBL) and problem-based learning (PBL). Project-based learning allows students to learn through projects that are challenging and relevant to the real world, while problem-based learning emphasizes authentic and contextual problem solving. According to Thomas[4], PjBL and PBL can help students develop the critical thinking, creativity, and collaboration skills needed in a complex and changing work environment.

Learning in SMK is often faced with several problems that need to be addressed comprehensively to improve the quality of education and its relevance to the needs of the industrial world. One of the main problems is the pattern of learning that is still traditional and less interactive. According to research by Jonassen et al.[5], traditional learning patterns, such as lectures and text-based teaching, tend to be less effective in producing deep understanding and maintaining student interest. This can result in students feeling bored and unmotivated in school.

Another problem is students' lack of motivation in participating in school learning. According to research by Wang et al.[6], factors such as a lack of a sense of relevance of learning to students' daily lives and a lack of social support can contribute to low student motivation in vocational schools. This can result in low participation rates, high absenteeism rates, and hindered learning quality.

The lack of readiness of SMK graduates in facing the industrial world is also a significant problem. According to research by Ling et al.[7], SMK graduates often lack skills that are in line with the demands of the world of work, such as technical skills, communication skills, and interpersonal skills. This can hinder their chances of getting a job that suits their field of expertise.

Based on data from the Central Statistics Agency (BPS) Open Unemployment Rate by Education Level, 2021-2023, which was updated on July 18, 2024. The Open Unemployment Rate (TPT) in Indonesia is dominated by vocational high school (SMK) graduates at 9,31 %. SMK is still the highest compared to other education level graduates. TPT is an indicator to measure the labor force that is not absorbed by the labor market.

The Open Unemployment Rate (TPT), which is an indicator to measure labor that is not absorbed by the labor market and illustrates the underutilization of labor supply, showed a significant trend from 5,45 % in February 2023 to 4,82 % in February 2024, or a decrease of 0,63 percentage points. The TPT by age group also shows that the unemployment rate is decreasing, especially in the productive age (25-59 years), from 3,95 % in February 2023 to 3,08 % in February 2024. When viewed based on the highest education completed by the labor force, the highest number of unemployed people came from Senior High School (SMA) and Vocational High School (SMK). It is quite sad considering that it is the labor force that has a fairly high education.

The TPT of SMK graduates is still the highest compared to other education levels, at 8,62 %, and in second place is the TPT of high school graduates at 6,73 %. Meanwhile, the lowest TPT is elementary school education and below, at 2,38 %. One of the main factors in the number of unemployed SMK graduates is that there is still a misalignment between the competencies of SMK graduates and the needs of the industry/world of work. Therefore, it is necessary to update the curriculum and competencies in order to meet the needs of the world of work (Taken from the CNBC INDOENSIA RESEARCH web page).

According to research by Marzano et al.[8], there are still many vocational students who have not reached the expected level of competence in various areas, including technical skills, creativity, and problem solving. This indicates the need for improvement in learning design that focuses on developing skills that are relevant to the needs of the industrial world.

To overcome these problems, collaborative efforts are needed between schools, industry, government, and other relevant stakeholders. The development of learning models by integrating learning models based on practice and technology, increasing the relevance of the curriculum to the needs of the world of work, strengthening student motivation through innovative approaches, and developing more holistic and integrated student skills and competencies are important steps in improving the quality of education in SMK and increasing the readiness of graduates to enter the industrial world.

SMK Negeri 1 Tanjungpinang, as one of the vocational schools located in the city of Tanjung Pinang, Riau Islands Province, produces graduates from various existing majors to be absorbed or work in the industry, has the same problem as other SMKs in general. The problem is that not all graduates of SMK Negeri 1 Tanjungpinang are absorbed by the industry or the world of work because they do not match the desired competencies.

The application of the STEAM learning approach has been proven effective in facilitating deeper and more meaningful learning for students. According to a study by Honey et al.[9], STEAM learning can increase students' interest in science and math and strengthen their critical and creative thinking skills. This model provides students with opportunities to explore concepts through real-world relevant projects, such as technology design, art making or science experiments.

The project-based learning (PjBL) model collaborated with the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach is an innovative learning model that supports the independent learning curriculum. The STEAM approach combines the power of science, technology, engineering, arts, and mathematics to make learning not only informative but also creative and applicable. Meanwhile, the project-based learning model brings students to the real world where they not only understand theoretical concepts but can also practice them in meaningful projects.

Project Based Learning - STEAM integrates both models and approaches. Students learn STEAM concepts while working on projects that require investigating and designing real solutions by applying knowledge. PjBL - STEAM has characteristics:[10]

1) Focuses on real-world problems.
2) Integrates several subjects.
3) Encourages students to actively design solutions.
4) Produce products/works and exhibit them.
5) Train 21st century skills: critical thinking, creativity, communication, and collaboration.

This research aims to develop a learning model needed in the development of the 21st century with the industrial revolution 4.0, namely by combining the project-based learning model (PjBL) with the STEAM learning approach utilizing android-based smart information technology to support the learning model in the independent learning curriculum. The learning model was tested and implemented in the Informatics subject, one of the subjects contained in the independent learning curriculum for phase E class 10 of SMK Negeri 1 Tanjung Pinang.

The objectives to be achieved in this study are Developing a STEAM-based Project Based Learning model (Science, Technology, Engineering, Art, Mathematics) integrated with android-based applications, Testing the validity of the STEAM-based Project-Based Learning model in informatics subjects in vocational schools, testing the practicality of the STEAM-based Project-Based Learning model in informatics subjects in validated vocational schools, and testing the effectiveness of the STEAM-based Project-Based Learning model in informatics subjects in vocational schools.

METHOD

Development Model

The method used in this research study is research and development (R&D), which aims to produce the development of learning model products. The development model used refers to the ADDIE model approach developed by Robert Maribe Brach in Sugiono[11] developed Instructional Design (Learning Design) with the ADDIE approach, which is an extension of Analysis, Design, Development, Implementation, and Evaluation.

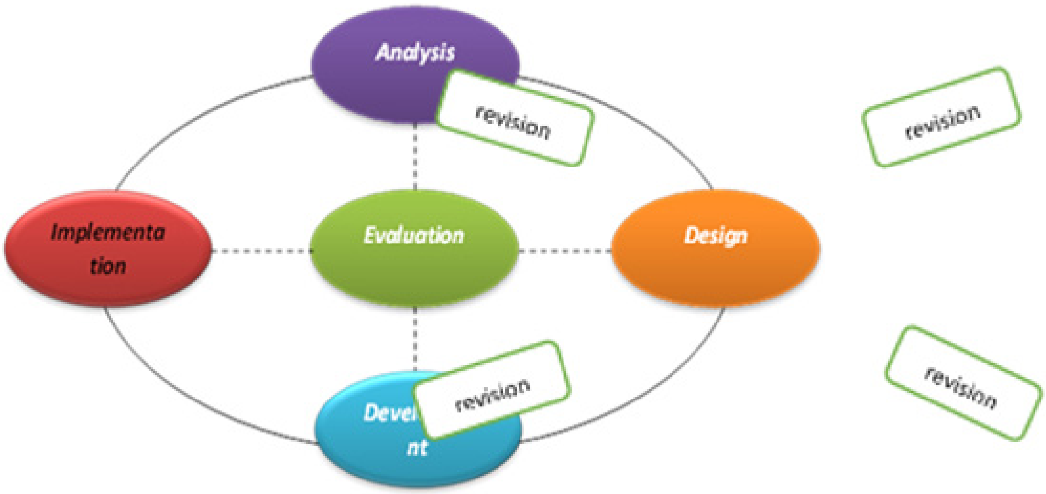

Figure 1. ADDIE Approach to Developing Learning Design Products[11]

Table 1. Stages of Procedure and Learning Model Development

No	Stages	Deskripsi
1.	Analysis	This stage is carried out with a preliminary study of need analysis through quantitative descriptive research using a field survey method.
2.	Design	Designing Project Based Leaning - STEAM Learning Model Development and designing supporting applications for android-based learning models (smart classroom)
3.	Development	Stages are carried out to create and validate products, as well as models that have been developed. The following are the products that were developed. 1) PJBL-STEAM Learning Model Book. 2) Informatics Teaching Book (Module). 3) Student Handbook. 4) Teacher's Handbook. 5) Supporting application for the Android-based PJBL-STEAM learning model (Smart Classroom).
4.	Implementation	This stage is carried out by testing the practicality of the model that has been developed and used by students.
5.	Evaluation	This stage is carried out by testing effectiveness based on cognitive, affective, and psychomotor aspects.

Product Trial

Product testing is a process carried out to test the developed product. Product testing is carried out by testing effectiveness through small-scale model tests and large-scale models. Can be seen in figure 3 below.

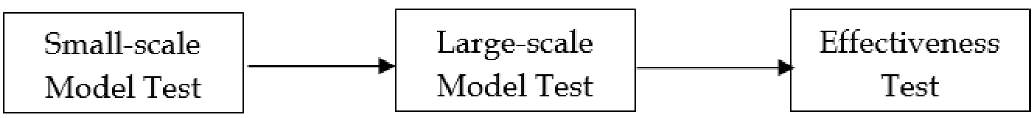

Figure 2. Product Trial

Small Scale Model Test

This test was conducted by applying the model directly to 30 students representing the Informatics class. The purpose of implementing this small-scale model is to minimize errors that may occur, and make improvements if there is something that needs to be improved in the development. Data was obtained from distributing questionnaires and direct interviews. This activity is carried out with an effectiveness test.

Large Scale Model Test

The large-scale test was taken 2 X classes from Accounting 1 and 2 majors who studied informatics subjects at SMK Negeri 1 Tanjungpinang. Each class consists of 30 students in one class and is grouped into experimental and control classes. Data was obtained from distributing questionnaires and direct interviews. This activity was carried out with an effectiveness test.

Test Subjects

The test subjects in this study were students of Sekolah Menengah Kejuruan (SMK) Negeri 1 Tanjungpinang, class X Akuntasi 1 (X AK 1) and Akuntasi 2 (X AK 2), who studied Phase E Informatics subjects. The data used consisted of primary and secondary data. Primary data in the form of questionnaires, and interviews to get the suitability of the needs of students in understanding and applying informatics subjects through field experts for later validation. Then there are questionnaires, observation sheets aimed at students, so that students can collect scores related to practicality and effectiveness. Secondary data comes from analysis conducted on the type of documents from the research.

Research Instruments

Validation Test Instrument

This validation test instrument is carried out by distributing questionnaires and interviews related to the learning model applied to experts.

Practicality Test Instrument

This practicality test instrument is carried out by distributing questionnaires related to the learning model applied to get the results of the practicality value of the teaching and learning process in the classroom carried out by the subject teacher.

Effectiveness Test Instrument

This effectiveness test instrument is carried out by distributing questionnaires related to the learning model applied to get the results/effectiveness value of learning outcomes based on cognitive, affective, and psychomotor aspects.

Data Collection Techniques

Direct communication techniques

Direct communication techniques, namely data collection, are carried out directly with respondents through interview guides.

Indirect communication techniques

Indirect communication techniques are data collection through intermediary tools; the tool used is a questionnaire.

Measurement technique

Measurement is done through giving cognitive, affective, and psychomotor tests to students to see the effectiveness of the STEAM-based project-based learning model in experimental and control classes.

Direct observation technique

Direct observation technique to observe the phenomena that occur, which is carried out directly and contains the indicators to be observed.

RESULTS

In this research, a learning model was developed that produced a STEAM-based project-based learning model with 8 learning syntaxes: 1) Start with a question (real question or challenge), 2) Research and discovery (research and discovery), 3) Plan the project (comprehensive project planning), 4) Create the project (create a solution or product), 5) Monitor and progress the projects (teacher monitors the development of student projects), 6) Test and iterate (continuous testing and revision), 7) Present the project (presentation of project results), and 8) Evaluate and reflect (evaluation and reflection on learning).

The product results in developing the STEAM-based Project-Based Learning learning model: 1) Project-

Based Learning - STEAM Learning Model Book, 2) Informatics Textbook, 3) Teacher's Guidebook, 4) Student's Guidebook, and 5) Android Smart Classroom-Based Learning Support Application. Research on developing the project-based learning-STEAM learning model uses the ADDIE (analysis, design, development, implementation, and evaluation) model development approach, with the following stages:

Results of Analysis

a) Foundations of Philosophical.
b) Foundations of Psychology.
c) Needs Analysis.

Results of the design

Designing STEAM-based Project Based Learning Syntax

Development of a STEAM-based Project Based Learning model, based on an adaptation of the project-based learning model developed by Lucas, STEAM-EDP and Laboy-Rush. Adapted according to effectiveness and efficiency, combining PjBL, STEAM, and Android-based Information Technology for Informatics subjects at Vocational Schools. The basis for developing the syntax of this learning model is to analyze the syntax contained in the Lucas and Laboy-Rush models, as well as the STEAM model, which are put together by removing the same syntax or syntax that is not needed.

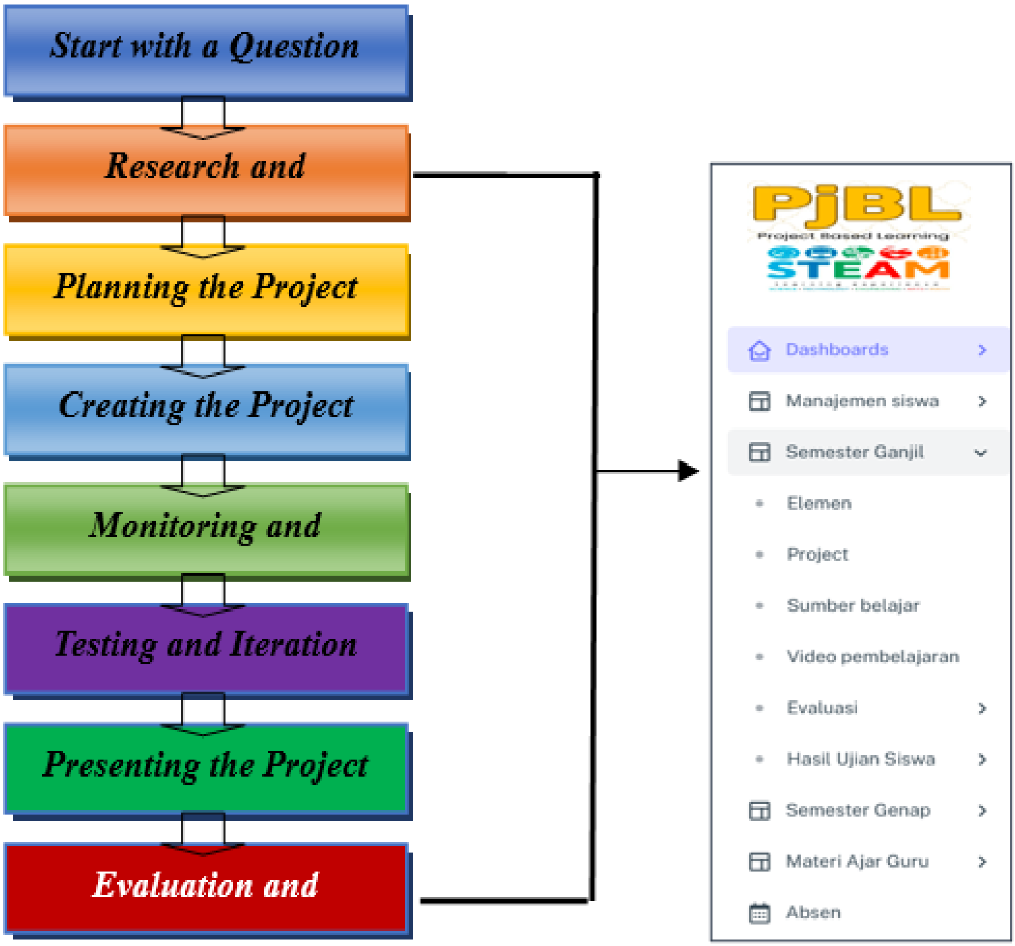

Figure 3. PJBL - STEAM learning syntax using the Android application (Smart Classroom)

STEAM Based PJBL Model Learning Structure

The learning model development structure consists of 5 main components:

1. Reaction Principle.
2. Social System.
3. Support System.
4. Instructional Impact.
5. Complementary Impact.

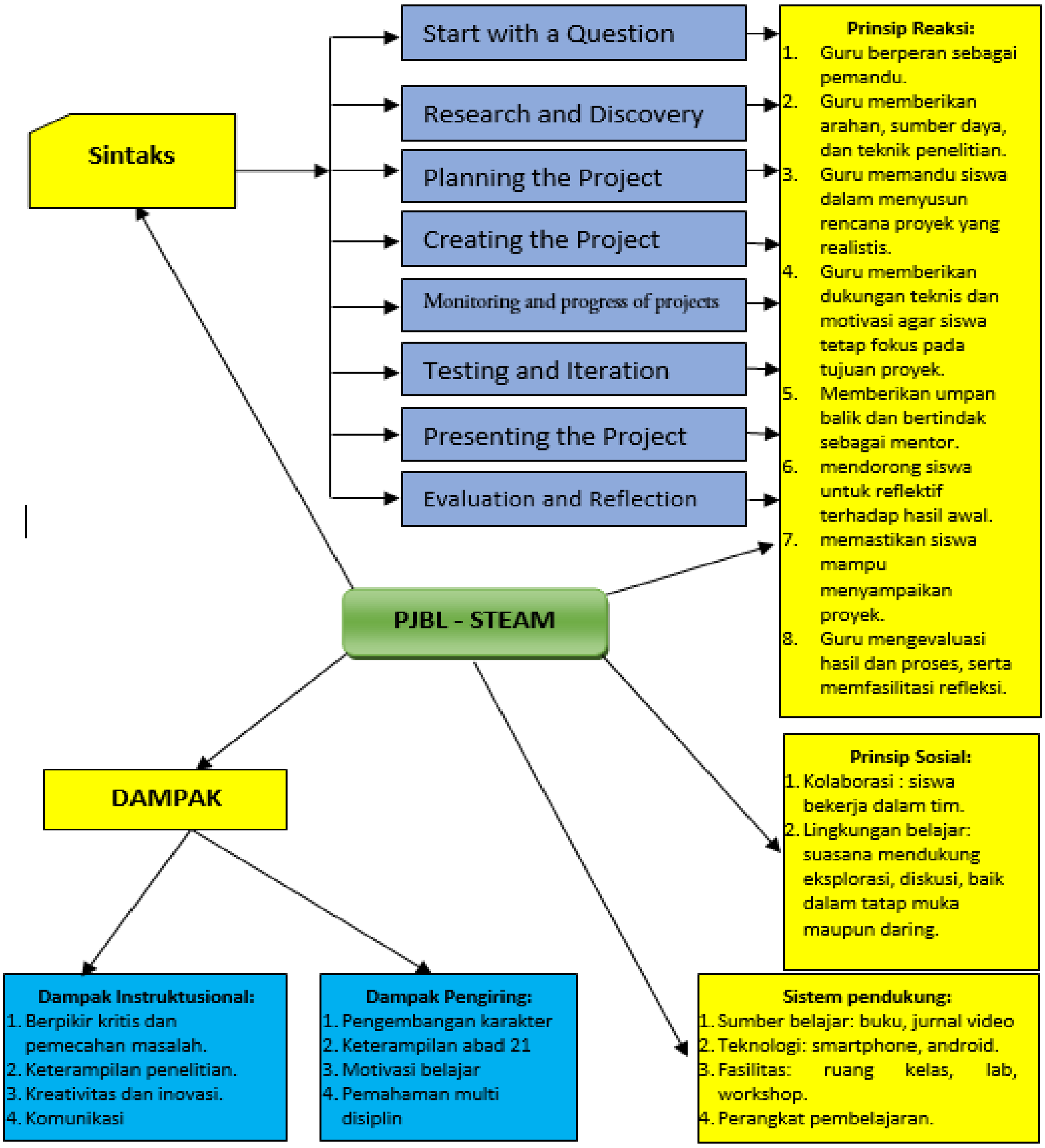

Figure 4. PjBL – STEAM learning model development structure (Hypothetical)

Development Results

Product Validity Analysis

The results of the validation analysis of the STEAM-based project-based learning model in informatics subjects can be described as follows:

Validation of Validity and Practicality Assessment Instruments

In this section, the validator provides an assessment (judgment) of the content (content) of the validity instrument to capture expert opinion on the product being developed. The validation results can be seen in table 2.

Table 2. Instrument Assessment Validity Analysis Results

No	Indicator Assessment	Skor V Aiken	Interpretation
1	Content appropriateness of the validity instrument	0,93	Valid
2	Language feasibility of the validity instrument	0,91	Valid
3	Validity of the instrument's graphic feasibility	0,91	Valid
4	Practicality instrument content feasibility	0,87	Valid
5	Practicality instrument language feasibility	0,89	Valid
6	Feasibility of practicability instrument graphics	0,89	Valid
Average		0,90	Valid

Thus the validation and practicality assessment instruments used in this study were declared valid from all aspects of the assessment, with an average of 0,90, a very high validity category. Therefore, the instrument can be used in assessing the STEAM-based project-based learning model for informatics subjects for vocational students.

Validation of Model Book

The validity of the learning model as outlined in the appearance of the STEAM-based Project-Based Learning model book for informatics subjects for vocational students, which is carried out through the validator's assessment.

Table 3. Model Book Validity Analysis Results

No	Indicator Assessment	Skor V Aiken	Interpretation
1	Model rationalization	0,88	Valid
2	Supporting Theory	0,88	Valid
3	Model Characteristics	0,90	Valid
4	Model Syntax	0,88	Valid
5	Social system	0,87	Valid
6	Reaction principle	0,89	Valid
7	Support system	0,91	Valid
8	Instructional impact and accompanying impact impact	0,91	Valid
Average		0,89	Valid

Results from table 3, for the results of the validity test of the model book against the validation instrument from the validator. Thus, the STEAM-based project-based learning model that has been developed is declared valid from all aspects of the assessment with a very high validity value.

Validity of the Teacher's Guidebook

The validity of the teacher's guidebook for Informatics subjects for vocational school students is carried out through assessment by a validator.

Table 4. Results of Validation Analysis of Teacher's Guidebook

No	Indicator Assessment	Skor V Aiken	Interpretation
1	Writing Format	0,86	Valid
2	Language Use	0,82	Valid
3	Introduction	0,75	Valid
4	Content Aspects	0,78	Valid
5	Evaluation System	0,79	Valid
Average		0,80	Valid

The results of the validation of the teacher's guidebook that has been developed are declared valid from all aspects of the assessment, with an average of 0,80 with a very high validity value.

Student Handbook Validity

The validator's assessment of the validity of the student guidebook can be seen in table 5:

Table 5. Result of Student Handbook Validation Analysis

No	Indicator Assessment	Skor V Aiken	Interpretation
1	Writing Format	0,86	Valid
2	Language Use	0,83	Valid
3	Introduction	0,79	Valid
4	Content Aspects	0,81	Valid
5	Evaluation System	0,81	Valid
Average		0,82	Valid

Thus, the student guidebook that has been developed is declared valid from all aspects of the assessment, with an average of 0,82 with a very high validity value.

Textbook Validation

The following is a description of the average results of the validator's assessment of the validity of textbooks, which can be seen in table 6.

Table 6. Results of Textbook Validity Analysis

No	Indicator Assessment	Skor V Aiken	Interpretation
1	Content Feasibility	0,91	Valid
2	Language Feasibility	0,90	Valid
3	Graphics	0,92	Valid
4	Presentation Feasibility	0,89	Valid
Average		0,91	Valid

Thus, the textbook that has been developed is declared valid from all aspects of the assessment, with an average of 0,91 with a very high validity value.

Implementation Results

Practicality Test

Practicality Based on Teacher Assessment

Table 7. Practicality Results Based on Teacher Assessment

No	Indicator Assessment	Skor V Aiken	Interpretation
1	Practicality of Learning Model	0,91	Praktis
2	Practicality of the Textbook	0,90	Praktis
3	Practicality of Teacher's Guide	0,90	Praktis
Average		0,90	Praktis

The results of the practicality of the teacher's assessment showed that the product developed contained the practicality of the learning model, the practicality of the textbook, and the practicality of the teacher's guide, having an average value of 0,90 with a very practical interpretation.

Practicality Based on Student Assessment

Table 8. Practicality Results Based on Student Assessment

No	Indicator Assessment	Skor V Aiken	Interpretation
1	Practicality of Learning Model	0,84	Praktis
2	Practicality of the Textbook	0,85	Praktis
3	Practicality of Student Guide	0,85	Praktis
Average		0,85	Praktis

The results of the practicality of the student assessment showed that the product developed contained the practicality of the learning model, the practicality of the textbook, and the practicality of the student guidebook, having an average value of 0,85 with a very practical interpretation.

Evaluation Results

Effectiveness Test

The results of the pretest and posttest cognitive aspects of informatics subjects are as follows:

Table 9. Results of Cognitive Aspects of Pretest and Posttest

Class	N	Mean Pretest	Mean Posttest
Experiment	30	61,20	87,4
Control	30	61,07	66,53

Homogeneity Test

The homogeneity test results can be seen in table 10.

Table 10. Homogeneity Test Results

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
nilai	Based on Mean	0,381	1	58	0,540
	Based on Median	0,042	1	58	0,838
	Based on Median and with adjusted df	0,042	1	55,294	0,839
	Based on trimmed mean	0,441	1	58	0,509

Based on the table above, it can be seen that the sig. value based on mean is 0,540, which is greater than 0,05. So it can be stated that the cognitive scores of the control class and experimental class are homogeneous. In addition, the Levene statistic shows the smaller the value, the greater the homogeneity. It is concluded that the experimental class and control class have the same variance.

Normality Test

Table 11. Normality Testing Results

One-Sample Kolmogorov-Smirnov Test			
		kelas_kontrol	kelas_eksperimen
N		30	30
Normal Parameters[a,b]	Mean	66,5333	87,4000
	Std. Deviation	9,64091	7,70401
Most Extreme Differences	Absolute	0,178	0,165
	Positive	0,130	0,165
	Negative	-0,178	-0,158
Test Statistic		0,178	0,165
Asymp. Sig. (2-tailed)[c]		0,160	0,360

Note: a. Test distribution is Normal. b. Calculated from data. c. Lilliefors Significance Correction. d. Lilliefors' method based on 10000 Monte Carlo samples with starting seed 926214481.

Based on table 11 above, the value of Asymp. Sig. (2-tailed) is greater than 0,05, namely 0,160 for the control class and 0,360 for the experimental class, so it can be concluded that the data of the two classes is normal.

Independent sample t-test (pretest data) was developed

The result of the test is that the Sig. (2-tailed) is greater than 0,05, namely 0,958, so that there is no difference in the pretest data of the experimental class and the control class. This is evidenced by the mean value, which shows that the average scores of the two classes are almost the same. So it can be assumed that both classes have the same initial ability and can be applied to the model developed.

Independent sample t-test (posttest data)

Based on the table above that the value of Sig. (2-tailed) is less than 0,05, namely 0,000 so that there are differences in cognitive learning outcomes of experimental and control classes after applying the developed model, this is evidenced by the mean value in the first table, which shows the average cognitive value of the experimental class (87,40) is greater than the control class (65,33). So it can be assumed that the model developed is effective.

Affective Aspect

Table 12. Affective aspect learning outcomes

Kelas	N	Mean	Std Deviation
Eksperimen	30	83,35	5,12
Kontrol	30	75,80	5,59

4 C Competency Assessment

It is known that the results of 4 Cs that contain competencies in the Project-Based Learning model obtained 4C results from critical thinking, creativity, communication, and collaboration indicators in project 1, averaging 84,27, 84,67, 84,33, and 86,00. While in the 2nd project the average was 83,87, 84,67, 85,00, and 87,11, in the 3rd project the average was 86,00, 85,00, 85,67, and 85,58, and for the 4th project the average was 85,33, 85,83, 86,78, and 86,00. The total average of these indicators from the whole project is Critical Thinking: 84,87, Creative: 85,04, Communication: 85,45, and Collaboration: 86,17. From these results, communication and collaboration abilities are higher than other competency indicators.

Psychomotor Aspect

The summary of project results per group shows that of the 3 groups of students who carry out project-based learning in informatics subjects, the results obtained in group one are an average of 79,25, 80,01, 83,78, and 85,19 for the four projects given. The second group has an average of 77,00, 79,16, 81,94, and 83,46. While the third group has an average of 76,69, 77,69, 80,52, and 82,95. It can be concluded that the average results of student projects from three groups consisting of 4 projects undertaken show an increase from each project.

DISCUSSION

The problem with vocational school education is that graduates are not fully graduates are not fully prepared to work because they do not have the skills that are needed in the world of work. This is one of the reasons why vocational high schools (SMK) contribute the most unemployed graduates.(12,13,14) unemployed graduates. In addition, graduates are often unable to compete with foreign workers, making them a spectator in their own country. so that they become spectators in their own country. This is also due to a learning gap that is limited to the classroom, learning models that are irrelevant to industry needs, not yet containing 21st century learning and the 21st century learning and the occurrence of transformational learning in the era of industrial revolution 4.0 in vocational education. For this reason, it is necessary learning that combines several learning models and supports the use of technology in learning.(15,16,17)

Project-based learning model (PjBL) which is collaborated with the STEAM approach (Science, Technology, Engineering, Arts, and Mathematics) as an innovative learning model that supports the independent learning curriculum. Model that supports the independent learning curriculum.(18,19) STEAM approach approach combines the strengths of science, technology, engineering, arts, and mathematics to make learning not only informative but also creative and applicable. Meanwhile, the project-based learning model model brings students to the real world where they not only understand the theoretical theoretical concepts but can also practice them in meaningful projects.(20)

Learning model development is carried out to achieve relevance between the competency needs of graduates and the world of work, which contains 21st century competencies in the era of the industrial revolution 4.0. contains 21st century competencies in the era of the industrial revolution 4.0, so in this case this is the development of a STEAM-based Project Based Learning model at vocational high school.(21) The results of previous research based on analysis conducted to meet the needs of developing a STEAM-based Project STEAM-based Project Based Learning model development in vocational high schools in the form of student analysis results, and based on learning needs in the 21st century to assess 4C and the era of the industrial revolution.(22) 21st century to assess 4C and the era of industrial revolution 4.0. In addition based on the analysis of the needs of the world of work that requires this competency and the needs of student characteristics. This competency and the needs of student characteristics, it can be concluded that it is appropriate to develop a STEAM-based Project Based Learning model.(23,24)

Theoretically building a model consists of five elements, a) Syntax/operational steps of learning, b) Social system; the atmosphere and norms that apply in learning, c) Principles of reaction; describes how the teacher should view and treat students, d) Support system; all facilities, materials, tools, or learning environment that supports learning, and e) Instructional impact; the learning outcomes obtained by the teacher. instructional impact; learning outcomes that are obtained directly based on the objectives specified and beyond specified. Development model has produced a product in the form of a STEAM-based Project Based Learning in informatics subjects in vocational high schools vocational (SMK), as for the products produced include: a) model book, b) textbook, c) teacher's guidebook, and d) student's guidebook.(25,26)

The product model developed is validated, that is includes: a) model books, b) textbooks, c) teacher's guidebooks, and d) books student guide. Validity test uses product evaluation techniques, namely expert review and focus group discussion. Expert review validation results have good resistance levels compared from validation techniques another. Results of validation carried out by validators on aspects The appropriateness of the content of the model product validity instrument is categorized as satisfactory scientific criteria in product development. The assessment with Aiken's V validity level was interpreted as 0,87 quite high (valid). Validation results of all indicators assessed validator from aspects of content feasibility, instrument language, and feasibility aspects The graphic category is valid and worthy of testing.[27]

This research fills a gap in the literature related to the integration of the Project Based Learning (PjBL) model, STEAM approach, and Android technology in informatics learning in vocational schools. By developing Android-assisted learning model equipped with with a comprehensive syntax and application-based evaluation system, this research offers an evaluation system, this research offers an innovative solution that can facilitate a more interactive, creative, and sustainable learning experience for vocational students in informatics.

CONCLUSIONS

This research has produced a STEAM-based project-based learning model in informatics subjects, producing several products, including learning model books, informatics textbooks, teacher guidebooks, student guidebooks, and Android-based application programs (smart classroom) to support the learning model. With the model syntax as follows: 1) Start with a question, 2) Research and Discovery, 3) Planning the projects, 4) Creating the project, 5) Monitoring and Progress of Projects, 6) Testing and Iteration, 7) Presenting the Project, and 8) Evaluation and Reflection. Product validity and supporting STEAM-based Project-Based Learning models in informatics subjects include STEAM-based Project-Based Learning model books, textbooks, teacher's manuals, and student manuals. Products in all aspects of the assessment are categorized as very valid, as evidenced by the analysis using Aiken's V test, so it is concluded that the STEAM-based Project-Based Learning model can be applied in learning. The practicality of the STEAM-based Project-Based Learning model can be seen from the implementation of the use of the model as a whole as well. The results obtained from teachers have a practical category, and the results of student practicality are also declared practical. The effectiveness of the STEAM-based project-based learning model has been measured, including aspects of the affective, cognitive, and psychomotor domains in experimental and control class students using conventional learning models with project-based STEAM approaches. The results prove that the STEAM-based Project-Based Learning model is more effective in improving student learning outcomes and improving and developing 4C competencies (soft skills) needed in 21st-century competencies.

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