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Developing a Stem Learning Project Model for Artificial Intelligence Courses

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Abstract

This study investigates the development of the STEM Learning Project model in artificial intelligence courses to enhance critical thinking skills by training students to analyze problems deeply and find effective solutions, as well as improve technical skills in machine learning, which include algorithms, classification techniques, regression, and clustering. Students possess good conceptual understanding and thinking abilities, but these do not always develop well. To address these challenges, this study introduces the STEM Learning Project model and finds that integrating STEM with project-based learning can increase student engagement and encourage critical and creative thinking. The syntax of this model, derived from existing project-based learning and STEM models, consists of 7 steps: 1) Formulating expected learning outcomes, 2) Determining application-based groups, 3) Planning and designing the project, 4) Performing project tasks and focusing on problems, 5) Testing products and presenting, 6) Evaluation and reflection, 7) Reward. The STEM Learning Project Model offers a promising approach to enhance student learning in artificial intelligence courses. By combining the strengths of STEM and project-based learning, this model can effectively develop students' critical thinking, problem-solving and technical skills. Future research could explore the long-term impact of this model on student achievement and professional development.

Keywords: *Artificial Intelligence, Critical Thinking, Project-Based Learning, STEM Learning Project, Technical Skill.*

Introduction

Lecturers must be creative and innovative in applying learning strategies to encourage students to use higher-order thinking skills. This aligns with the demands of 21st-century skills such as critical thinking, creativity, problem-solving, and decision-making. Based on interviews with artificial intelligence course lecturers at several universities, the learning process has included project assignments, but these have primarily been individual projects. Students also struggle to develop techniques for absorbing information from lecturers. According to [1] students essentially have good conceptual understanding and thinking skills, including critical thinking, but these skills sometimes do not develop well.

To answer these challenges, the development of a project-based learning model with a STEM approach in artificial intelligence courses needs to be introduced. According to [2] STEM-based project-based learning can improve students' science process skills and creative thinking. STEM-based project-based learning is expected to be a reference in the application of STEM-based project-based learning. The results showed that the PBL technique increased student engagement by enabling knowledge and information sharing and discussion. Thus, the PBL approach is highly recommended for educational use by students and should be encouraged in universities [3] However, the implementation of this model is not without barriers. One of the main challenges identified by Johnson (2020) is the readiness of lecturers in designing and managing projects that fit the curriculum and students' needs. Therefore, support and training for lecturers are crucial to ensure the successful implementation of this learning model.

[4] explained that students' interest, creativity, critical thinking, and communication in STEM are important goals that must be achieved in the learning process. Then science and mathematics become more fun to learn the actualization through engineering and technology in order to increase creativity, and convergent talent in solving factual problems in the learning process. By adopting the STEM Learning Project model, it is expected that students will not only better understand the concept of artificial intelligence in depth, but also be able to apply the knowledge in real situations, which in turn can improve their readiness to face

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future challenges.

The Project-Based Learning model is an active method and involves learners directly to improve their thinking skills in dealing with problems found. Project-based learning and STEM have their own advantages and disadvantages. Both models have the same characteristics in the approach pattern which is student centered learning and emphasizes student independence in finding the solution pattern based on their respective knowledge. However, the STEM approach focuses more on the use of science and technology, and Mathematics determines students to complete projects or tasks and problems in a structured and systematic manner [5]) emphasizes that: "STEM had its origins in the 1990s at the National Science Foundation (NSF) and has been used as a generic label for any event, policy, program, or practice that involves one or several of the STEM disciplines". Bybee's idea emphasizes and explains that the ability of students to interpret knowledge, events, and programs must involve Science, Technology, Engineering, and Mathematics in order to be able to be intact in constructing their experiences and knowledge. And if STEM is elaborated into a STEM learning project model. To address these challenges, the development of a project-based learning model with a STEM approach in artificial intelligence courses needs to be introduced. According to [6] project-based learning Both models (project-based learning and STEM) if developed and elaborated into a learning model will be a solution for the development of today's world of education which is faced with the dynamism of scientific and technological developments that make higher education graduates must be adaptive in facing highly competitive global competition. This model is assumed to be a reformer in facing the challenges of the current world of education, where every course in higher education must be able to produce competitive and adaptive outputs and outcomes in the face of highly competitive global competition and all of this is determined by the abilities possessed by students and graduates, especially mastery of knowledge and optimization of technology.

One of the courses or knowledge that forms the basis of this competition is Artificial Intelligence (AI). AI, which is now one of the main pillars in the industrial revolution 4.0 [7] is a compulsory course in informatics engineering study programmes, but nowadays almost all scientific clusters make it a compulsory course. This is in line with the findings of which show that AI has great potential to revolutionise various sectors, from healthcare to manufacturing. This course aims to improve students' ability in computer programming algorithms to be able to imitate the intelligence of experts in various scientific fields so that the birth of new information technology that can help and do human work.

Related to the problems raised in the artificial intelligence course above, it is necessary to develop an effective learning model considering that the purpose of this course is very central in cross-disciplinary development. As emphasised by [8] AI has become an interdisciplinary technology. Therefore, the development of such a learning model, for example by adopting a project-based learning model as proposed by [9] can improve students' productive competencies, especially in Artificial Intelligence courses and students are able to visualise competencies by solving factual problems that exist around them. Collaborative learning through online platforms, as proposed by [10] can also be one of the effective approaches. The project model of STEM learning is a good application of the model conceptually and critically thinking, which causes students to gain experience and learning that is easier to understand. As emphasised by [11] project-based learning provides students with opportunities to develop deep knowledge and critical thinking skills. And even the application of this model can map the experiences that students have in the learning process, as can be done through a learning portfolio as described by [12].

STEM skills possessed by students are able to formulate a chronology of problems presented in learning, then become concrete knowledge in everyday life. This learning model focuses on the visualisation of learning materials, problems, and evaluation of tasks or projects done to other students comprehensively so that it is easier to understand in the learning process which is closely related to real problems in society, as emphasised [13] who states the importance of connecting STEM learning with real-world problems. This model is also in line [14]) findings that visualisation can improve students' understanding of complex concepts.This is in line with [2] PjBL model with STEM approach affects students' concept understanding and creativity.

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Materials and Methods

The data in this study were taken from learning outcomes data in the form of pretest and posttest scores. The initial ability of students is measured from pretest scores in artificial intelligence courses totalling 30 people. While the posttest is used to determine the final ability after applying the STEM Learning Project model. Before the research was conducted on the application of STEM Learning Project, the instruments in the form of pretest and posttest questions used had been measured for validity by validators in accordance with their respective fields. Data analysis in this study was processed using Microsoft Office Excel 2019 and SPSS 27.0 software.

Validity Test

A question is said to be valid if the question can measure what it is intended to measure and has correct support for the total score. To calculate the validity of the test can use the formula [15] such as:

$$\gamma_{pbi} = \frac{Mp - Mt}{St}\sqrt{\frac{p}{q}}$$

Keterangan: γ_{pbi} = Koefisien korelasi point-biserial
M_p = Skor rata-rata hitung untuk butir soal yang benar
M_t = Skor rata-rata dari skor total
S_t = Deviasi standar dari skor total
p = Proporsi peserta didik yang menjawab benar terhadap butir soal yang sedang dicari validitas nya
q = 1 – p (proporsi peserta didik yang menjawab salah)

Then the price is adjusted to the table price at the 5% significance level if it is calculated < table then the item is not declared valid. Based on the validity analysis of 50 pretest test questions, 42 questions were found valid and 8 questions were invalid. As for the posttest test questions, 42 valid questions and 8 invalid questions were obtained.

Reliability Test

Reliability of a test when used on the same subject. A test can be said to have a high level of determination if the test can provide constant results. The reliability test is carried out to determine the level of fixity of a test when carried out on the same subject. For this reliability, the formula is used.

$$r_{11} = \left(\frac{n}{n-1}\right)\left(\frac{s^2 - \sum pq}{s^2}\right)$$

Keterangan: $r11$ = Reliabilitas instrument
n = Banyaknya item
$\sum pq$ = Jumlah varians skor butir
s^2 = Varians skor total

Klasifikasi reliabilitas tes disajikan pada tabel 1 [16].

Table 1. CLASSIFICATION OF SOAL RELIABILITY

No	Koefesien Korelasi	Kriteria
1	0,800-1,00	Sangat Tinggi
2	0,600-0,800	Tinggi
3	0,400-0,600	Cukup
4	0,200-0,400	Rendah
5	0,00-0,200	Sangat Rendah

Based on the reliability analysis of the pretest and posttest test questions for the pretest question has a reliability value of 0.876 with a very high category. of 0.850 with a very high category. Meanwhile, the posttest question has a reliability value of 0.90 with a very high category.

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Problem Difficulty level

The test of the level of difficulty of the question is a number that indicates whether the question made is including difficult, moderate, or easy. The level of difficulty of the question is determined using the following formula as follows:

$$P = \frac{B}{JS}$$

Description: P = Index of difficulty

B = The number of samples that answer the question correctly

Js = Number of samples that answer the question

The classification of the question difficulty index can be seen in table 2 [16].

Question Difficulty Index	Classification
0,00-0,03	Difficult
0,31-0,70	Medium
0,71-1,0	Easy

In the calculation of the question difficulty index, for the pretest test questions, there were 37 questions in the medium category, and 13 questions in the easy category. 35 questions, and 15 questions in the easy category. In the calculation of the question difficulty index, for the posttest test questions, there were 35 questions in the moderate category, and 15 questions in the easy category questions.

Calculating the Distinguishing Power Index

The index of distinguishing power of a question item is an indicator to distinguish between students who are smart (high ability) and students who are stupid (low ability), (high ability) with students who are stupid (low ability).

$$D = \frac{B_A}{J_A} - \frac{B_B}{J_B} = P_A - P_B$$

Keterangan: D = Daya pembeda soal
B_A = Jumlah kelompok atas yang menjawab soal benar
B_B = Jumlah kelompok bawah yang menjawab soal benar
J_A = Jumlah peserta kelompok atas
J_B = Jumlah peserta kelompok bawah

The classification of the index of distinguishing power can be seen in table 3 [16].

Divisibility Index	Classification
0,00-0,20	*ugly*
0,21-0,40	*enough*
0,41-0,70	*good*
0,71-1,00	*very good*

In the analysis of differential power, for the pretest test questions out of 50 questions there were 2 questions in the bad category, 10 questions, 28 questions in the fair category, 11 questions in the good category, and no questions in the good category.

questions, 9 bad questions, 26 questions in the moderate category, 13 questions in the good category, and no questions in the excellent category. questions in the excellent category. Meanwhile, for the posttest test questions out of 50 questions there were bad category questions as many as 6 questions, 30 questions in the fair category, 14 questions in the good category, and no questions in the good and excellent categories.

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good and excellent categories.

Results

Analysis of Question Validity

In this study, the questions were designed in the form of 50 multiple-choice items. These questions were administered to participants who were not part of the control or experimental groups. The questions were given to 30 students to measure their validity. The validity of a test question is the degree to which it accurately measures what it is supposed to measure.

Based on the validity analysis conducted on the test items developed in accordance with the subject matter of the Artificial Intelligence course, out of 50 test items, 12 were found to be invalid while 38 were declared valid. The 12 invalid items were questions numbered 6, 8, 12, 13, 19, 21, 24, 28, 30, 32, 33, and 38. The determination of the validity of the questions was obtained from the calculation of the correlation coefficient ($\gamma\rho$bi). These results were identified because each item had an r-table value of 0.361.

Reliability Analysis of Questions

The next test conducted on the test items is the reliability test. This test is used to determine the accuracy of the measurement tool in measuring the reliability of the questions. Based on the calculations using the reliability test of the instrument on the test items, if the Cronbach Alpha value is > 0.6, it is considered reliable. The reliability calculation results showed a Cronbach Alpha value of 0.931, indicating that the questions are reliable.

Question Difficulty Level

The difficulty level of a question indicates how hard or easy the question is. From the 50 test items administered to 30 students, it was found that 15 questions were categorized as easy, 29 questions as moderate, and 6 questions as difficult. The easy questions were numbered 8, 10, 14, 19, 20, 22, 26, 30, 36, 37, 38, 39, 41, 43, and 48. The difficult questions were numbered 9, 17, 18, 44, 45, and 46.

In this study, the experimental class applied the STEM Learning Project model, while the control class applied conventional learning. The following are the learning outcomes of students from experimental and control classes based on cognitive aspects.

Table 4. Student Cognitive Learning Outcomes

Kelas	N	Mean Pretes	Mean Postes
Eksperimen	30	53,30	83,17
Kontrol	28	45,74	74,95

Based on cognitive results in the experimental class in the pretest of 53.30 and posttest of 83.17. For the control class the pretest was 45.74 and the posttest was 74.95. The pretest value graph is as follows.

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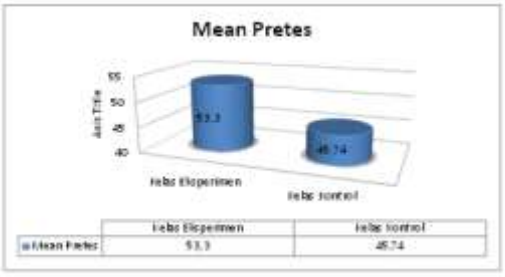

The graph above presents the mean pretest scores of two distinct groups: the experimental group and the control group. These pretest scores likely represent the initial scores obtained by the students before any treatment or specific instruction was provided. Based on the data presented, it can be concluded that there is a significant difference in initial ability between the experimental and control classes. The experimental class has better initial ability compared to the control class.

Conclusion

Based on the results and discussions presented, as well as the research objectives regarding the development of the STEM Learning Project model in the Artificial Intelligence course, it can be concluded that this study successfully developed an effective learning model. The development of the STEM Learning Project model involved the creation of four main products: a model book, teaching guide, student guide, and teaching module. These products aim to make learning Artificial Intelligence more interactive, applicable, and aligned with the latest technological advancements.

Additionally, the developed STEM Learning Project model has been proven to be valid, practical, and effective. Its validity was tested by experts in the relevant fields, while its practicality and effectiveness were tested by involving lecturers and students through class experiments. The test results indicate that using this model significantly improves learning outcomes between the experimental and control classes, suggesting that this model can enhance students' abilities in cognitive, psychomotor, and affective domains.

The achievement of students' technical skills in the Artificial Intelligence course also showed significant improvement after using the STEM Learning Project model. Students were trained to analyze problems deeply, find effective solutions, and understand machine learning algorithms, classification techniques, regression, and clustering. This demonstrates that this learning model can enhance students' critical and technical thinking skills.

The implication of this research is that the STEM Learning Project model can be effectively applied in various courses that have similar characteristics to Artificial Intelligence. This model has 7 syntaxes, namely: 1) Formulating expected learning outcomes, 2) Application-based group determination, 3) Developing project planning, 4) Carrying out project tasks, 5) Product testing and presentation, 6) Evaluation and reflection and 7) reward. This model not only improves learning outcomes in the three main domains but also enriches theoretical understanding and prepares students to face practical challenges in the world of work. For successful implementation, intensive training and workshops for lecturers are highly recommended, and further trials in various courses are needed to ensure the effectiveness of this model.

In supporting the STEM Learning Project model, it is supported by an application for the implementation of syntax 2, namely the determination of application-based group members is a method that utilizes technology to form more effective and efficient groups. By using algorithms and relevant data, the application can optimize the composition of members in each group. so that the application can provide meaningful support in the implementation of this model. the same thing is also conveyed by [17] An intelligent learning environment with the implementation of the app will allow students to learn from their experiences, adapt to new inputs, and perform project tasks that have been assigned to lecturers.

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