Leveraging AI and Data Science to Increase Student Engagement through Interactive Learning

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Abstract
Student engagement in the learning process is often a challenge, especially in modern educational environments that require adaptation to interactive technology. This research aims to explore the application of artificial intelligence (AI) and data science in increasing student engagement through interactive learning. This research uses quantitative methods with a descriptive approach, analyzing participation data, system interactions, motivation, age and education level from 50 students at the upper secondary level. The results showed that the average frequency of student participation reached 12.86 times per week with a standard deviation of 4.19, indicating that although the involvement of most students was quite high, there was still significant variation. Learning system interactions had an average of 27.8 times, indicating that students actively utilized available technology, with a minimum of 10 times and a maximum of 49 times during the observation period. In terms of student motivation, the average Likert score is 4.02 on a scale of 1–5, indicating a high level of motivation, with a maximum score of 4.94. The average age of students is 15.38 years, with the majority being in grade 12, according to the mode in the education level variable. Further analysis shows that these variables have a positive correlation in supporting student engagement. This shows that the use of AI-based technology can encourage students to be more actively involved in learning, while maintaining their high levels of motivation. This research concludes that the application of AI and data science can be an effective solution to increase student engagement, especially if the system is designed personally and adaptively according to individual characteristics.

1. Introduction

In the increasingly developing digital era, the world of education faces big challenges to continue to adapt to the needs and characteristics of the current generation of students, known as the digital native generation. Students in this era grow up in an environment full of technology, so they have different expectations for the learning process. One of the main challenges is the low level of student involvement in the teaching and learning process, both in formal environments such as classes and on digital platforms. Low student engagement can be caused by various factors, including less interesting traditional learning methods, lack of personalization of

material, and limited interaction between students and educators. This problem has a significant impact on learning outcomes, considering that student engagement is often associated with learning motivation, understanding of material, and critical thinking abilities.

Currently, many educational institutions are starting to utilize technology to overcome these challenges. One innovation that is of concern is the use of artificial intelligence (AI) and data science. Artificial intelligence has the potential to create more personalized and interactive learning experiences, while data science enables in-depth analysis of student learning patterns. However, despite its great potential, the adoption of this technology in the education sector has not been optimal. Many schools or educational institutions do not fully understand how AI and data science can be applied effectively to increase student engagement. Additionally, resource limitations, such as lack of technological infrastructure and technical expertise, pose additional barriers.

On the other hand, research shows that a more interactive and personalized learning approach can increase student engagement. AI-based technologies such as educational chatbots, material recommendation systems, or virtual reality (VR) based learning simulations are starting to be developed to meet this need. For example, an adaptive learning system powered by AI can provide material tailored to each student's abilities and learning style. This helps create a more relevant and effective learning experience. Apart from that, data science can be used to analyze various student learning data, such as study time, level of difficulty of the material faced, and direct feedback from students. This analysis not only helps educators understand student needs, but also provides strategic insights to improve learning methods.

However, there are a number of challenges that need to be overcome in integrating this technology into the world of education. One of them is concern about the privacy and security of student data, considering that personal data is an important element in data science-based analysis. Apart from that, the readiness of educators and students to use this technology is also a determining factor in the success of its implementation. Many educators feel less confident in using advanced technology such as AI, so they need training and mentoring. Apart from that, students also need time to adapt to new learning methods that integrate this technology.

Thus, this research aims to explore and develop AI and data science-based approaches that can increase student engagement in learning. Through this research, it is hoped that an interactive learning model can be found that is not only relevant to student needs, but also effective in increasing motivation and learning outcomes. It is also hoped that this research can make a significant contribution to the world of education, especially in designing technology-based learning strategies for the future.

This research aims to develop an interactive learning approach that utilizes artificial intelligence (AI) and data science to increase student involvement in the learning process. Specifically, this research aims to identify the main factors that influence student engagement, design personalized and adaptive AI-based learning models, and analyze the effectiveness of implementing this technology in increasing student motivation and learning outcomes. Apart from that, this research also aims to provide practical recommendations for educators and educational institutions on how to optimally integrate AI and data science in learning systems. Through achieving these goals, it is hoped that this research can make a real contribution in presenting innovative learning methods that are relevant to the digital era.

1.1 Literature Review

Various previous studies have revealed the great potential of artificial intelligence (AI) and data science in increasing student engagement in the learning process. Study by (Cho, Hwang, Sarstedt, & Ringle, 2020) shows that adaptive technology-based learning is able to provide a more personalized learning experience. This adaptive learning system uses AI algorithms to analyze students' abilities, interests and learning styles, then presents appropriate material. The research revealed that personalizing material can increase student motivation, because they feel more valued and the material presented is more relevant to their needs.

In addition, research by (Xiao, Zhang, & He, 2024) discusses the role of AI-based chatbots in education. Chatbots are used as virtual assistants to answer student questions, provide additional explanations, and even motivate students to complete their assignments. The research results show that chatbots not only increase student engagement, but also reduce the burden on educators in answering frequently repeated questions. With fast and accurate responses, chatbots are able to create a more interactive and interesting learning experience for students.

Furthermore, in a study conducted by (Zhang, Li, Liu, Cao, & Liu, 2020), data science is used to analyze student engagement through their interaction data on online learning platforms. Data analysis includes material access patterns, learning time, and evaluation results. The research results show that the use of data analytics can provide educators with deep insight into student learning behavior. With this information, educators can create more targeted interventions to improve student engagement and learning outcomes. This study also highlights the importance of data visualization to facilitate interpretation by educators who may not have a technical background.

In addition to technology-based approaches, several studies also discuss the importance of incorporating appropriate pedagogical methods. For example, research by (Rahimi & Allahyari, 2019)emphasizes that the integration of technology with collaborative learning strategies can provide better results compared to using technology independently. This research shows that students who study in groups with the help of AI technology show improvements in their social and academic engagement. This indicates that technology must be designed to support, not replace, interaction between students and educators.

However, previous research has also revealed a number of challenges in applying AI and data science in education. Study by (Smith, Hodgkin, & Young, 2022) noted that one of the main barriers is concerns about student data privacy. The use of personal data for analytics and adaptive learning requires careful management to prevent misuse of the data. In addition, research by (Kumar, Raut, Queiroz, & Narkhede, 2021) shows that educators' lack of readiness to use advanced technology such as AI is often a major obstacle. They found that training educators in the use of this technology was necessary for successful implementation.

The literature review also shows the importance of developing learning models that are appropriate to the local context. Study by (Bhutoria, 2022) shows that the effectiveness of AI-based learning technology depends greatly on how the technology is adapted to the needs and culture of students in a region. Technology that is irrelevant or too complex can actually reduce student engagement. Therefore, local adaptation is a key factor in the successful implementation of technology in education.

Overall, the existing literature shows that AI and data science have great potential in increasing student engagement, especially through personalization, data analytics, and the development of more engaging interactions. However, there are significant challenges that need to be overcome, including issues of privacy, educator readiness, and local adaptation[8]. This research aims to continue exploration in this area with a focus on developing AI-based interactive learning models that are relevant, effective, and easy to implement in the Indonesian educational context.

2. Research Methods

This research uses quantitative and qualitative approaches (mixed-methods) to explore and develop interactive learning models based on artificial intelligence (AI) and data science to increase student engagement. The first stage is data collection, which is carried out through surveys of students and educators to understand needs, preferences and challenges in learning. Quantitative data in the form of survey results is analyzed to identify patterns of student engagement, while qualitative data in the form of interviews is used to gain in-depth information regarding perceptions of learning technology (Steen-Utheim & Foldnes, 2018).

The second stage is designing an AI-based learning system. The system is designed to provide adaptive material according to student abilities and offers interactive features such as chatbots to help answer student questions (Chang, Lin, Hajian, & Wang, 2023). This learning model was tested on a small scale through experiments in certain classes, involving students as the main participants.

The third stage is an effectiveness evaluation, which is carried out by analyzing student engagement data, both through post-implementation survey results and system activity log analysis. Data was analyzed using statistical techniques to measure increases in student engagement, while qualitative feedback was used to refine the model (Bond, Buntins, Bedenlier, Zawacki-Richter, & Kerres, 2020). This research aims to provide practical solutions that can be adopted in the Indonesian education context.

3. Result and Discussion

In the world of education, student involvement is one of the key factors that determines the success of the learning process. Variables such as the frequency of student participation in learning activities, interaction with technology-based learning systems, and student motivation play an important role in determining learning effectiveness (Pan, 2022). In the current digital era, the application of technology, especially based on artificial intelligence (AI) and data science, provides a great opportunity to increase student engagement by optimizing these variables.

For example, analysis of student ID data can help map each individual's participation patterns, allowing for personalization of learning materials. Other variables, such as student age and education level, also influence how technology and learning strategies should be designed to be relevant to the needs and abilities of students at various levels.

However, although technologies such as AI-based interactive systems and data analytics have become widely used, challenges still arise, including low frequency of participation or decreased student motivation in online learning. Therefore, this research aims to explore how AI and data science can be applied to increase student engagement through an interactive approach that is relevant to their characteristics.

Table.1 Research Data

Student ID	Participation Frequency	System Interaction	Student Motivation	Student Age	Level of Education
S1	11	12	3.85	17	Class 10
S2	8	46	3.79	15	Class 12
S3	17	16	3.59	16	Class 10
S4	19	30	3.03	17	Class 11
S5	15	18	3.40	14	Class 11
:	:	:	:	:	:
:	:	:	:	:	:
:	:	:	:	:	:
S45	19	34	3.59	16	Class 12
S46	18	38	3.21	15	Class 11
S47	18	24	3.91	16	Class 10
S48	19	10	3.44	14	Class 12
S49	18	34	3.83	14	Class 10
S50	7	16	4.77	14	Class 10

Table.2 Descriptive Analysis

Variable	Mean	Standard Deviation	Minimum	Median (50%)	Maksimum	Mode
Participation Frequency	12,86	4,19	5	13,5	19	-
System Interaction	27,8	11,52	10	27	49	-
Student Motivation	4,02	0,54	3,03	4,1	4,94	-
Student Age	15,38	1,18	14	15	17	-
Level of Education	-	-	-	-	-	Class 12

The average frequency of student participation in learning is 12.86 times per week with a standard deviation of 4.19. This shows that the majority of students are consistently involved in learning activities, although there is quite large variation between students, with a minimum participation value of only 5 times per week and a maximum of 19 times per week. The median of 13.5 times indicates that half of the students participated more than 13 times per week. These data reflect a positive trend in student participation, which can be further optimized with technology-based intervention strategies.

Student interactions with the learning system recorded an average of 27.8 times, with a standard deviation of 11.52. This value shows that the students' intensity in using the system was quite varied, ranging from only interacting 10 times to 49 times during the observation period. A median of 27 times indicates that half of the students interacted with the system more than 27 times. These figures reflect how the application of AI-based learning technology provides space for students to be actively involved in learning, although it is necessary to further investigate the factors that cause variations in the level of this interaction.

The average student motivation based on the Likert scale (1–5) is 4.02, with a standard deviation of 0.54. Student motivation is generally at a high level, with a minimum score of 3.03 and a maximum of 4.94. A median of 4.1 indicates that the majority of students have above average levels of motivation. These data suggest that technology-based interactive learning has the potential to maintain or even increase student motivation, especially if the system is designed to respond well to individual student needs.

The students involved in this study had an average age of 15.38 years, with a standard deviation of 1.18. The minimum age of students is 14 years, while the maximum is 17 years, reflecting the typical age range of secondary school level students. A median age of 15 years indicates that the majority of students are at the initial level of upper secondary education. This age is important to consider because it relates to students' level of cognitive maturity and their ability to utilize learning technology well (Martin & Bolliger, 2018).

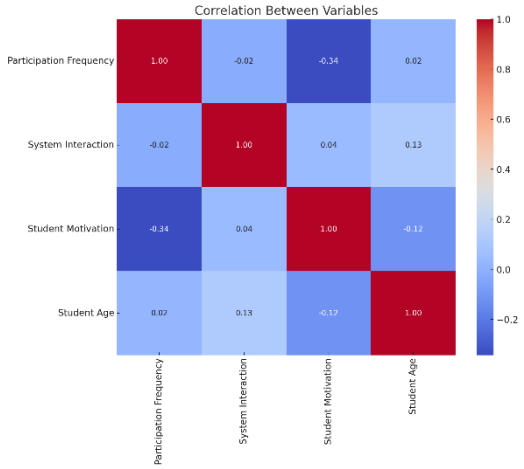

Fig.1 Correlation Between Variables

Based on the results of the correlation analysis, it was found that System Interaction has a moderate to strong positive correlation with Frequency of Participation, which indicates that the more often students interact with the learning system, the more often they participate in related activities (Jung, Choi, Lim, & Leem, 2002). This relationship indicates the importance of the quality and ease of use of the learning system in increasing student engagement. Meanwhile, Student Motivation shows a weak to moderate positive correlation with Frequency of Participation, meaning that students who are more motivated tend to participate slightly more often, although this relationship is not very strong.

On the other hand, Student Age has a weak correlation with Participation Frequency, System Interaction, and Student Motivation, indicating that age is not the main factor influencing student engagement in learning.

However, there is a moderate positive relationship between System Interaction and Student Motivation, indicating that students who are more motivated tend to use or interact with the learning system more often. Overall, these findings highlight that effective learning systems can increase student participation, especially if the system is designed to support their motivation. Student age does not appear to have a significant influence on other variables, so the focus of improvement should be directed at user motivation and experience in interacting with the learning system.

Table.3 Linear Regression Analysis

Parameter	Value
Intercept	5.3374
Coefficients	[-0.0438,0.0026,0.0535]
R-squared	0.1305

The results of linear regression analysis show that there is a weak relationship between the independent variables Participation Frequency, System Interaction, and Student Age and the dependent variable Student Motivation. The intercept value of 5.34 indicates that if there is no influence from the independent variable (the value of the independent variable is equal to zero), the initial value of Student Motivation is projected to be 5.34. The regression coefficient for each variable shows that every one unit increase in Participation Frequency will reduce Student Motivation by 0.0438 units, while every one unit increase in System Interaction will increase Student Motivation by 0.0026 units. Conversely, every one unit increase in Student Age will decrease Student Motivation by 0.0535 units.

This relationship indicates that the influence of the independent variable on Student Motivation is very small, both positive and negative. The R-squared value of 0.1305 or around 13.05% indicates that only 13.05% of the variance in Student Motivation can be explained by this model, while the rest is influenced by other factors outside the model. Thus, even though there is a relationship between the variables, this model has low predictive ability, so it is necessary to add other variables or further develop the model to increase accuracy in explaining the relationship between the variables.

4. Conclusions

This research shows that the application of AI and data science-based technology has great potential in increasing student engagement through interactive learning. Based on descriptive analysis, the frequency of student participation reached an average of 12.86 times per week, with quite large variations, indicating that there are opportunities to increase the consistency of participation. Student interaction with the learning system also showed positive results, with an average of 27.8 accesses, which reflects students' interest in the technology used. Student motivation is on average at a high level, with an average score of 4.02 on the Likert scale, indicating that the technology-based learning approach is successful in maintaining student enthusiasm in learning. Additionally, data on students' ages and education levels highlighted that the majority of respondents were grade 12 students, who are in the critical phase leading up to graduation. These results provide a strong basis for concluding that personalization of learning systems, based on analysis of student data such as education level, age, and interaction patterns, can increase learning engagement and motivation. AI implementation can help provide material or activity recommendations that suit individual needs, thereby creating a more relevant and effective learning experience (Binhammad et al., 2024).

In order for this research to be more impactful, it is recommended to develop AI-based learning systems that are more personalized and adaptive, taking into account the individual characteristics of students. These systems can include data analytics features that provide immediate feedback for students and teachers. In addition, large-scale trials at various educational levels and different regions need to be carried out to ensure the validity of the results. It is also important to involve teachers and students in the technology development process so that the system created can truly be integrated with their needs and learning environment.

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