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Impact of Virtual Worlds on Student Engagement and Academic Performance: An Analysis of Online Learning Using Second Life Technology

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Abstract

The metaverse is a virtual world with immense potential and is increasingly adopted as an online learning platform for students. Students can build virtual worlds that simulate real-life experiences using interactive activities. In this study, we implemented student learning in the virtual world and evaluated the effects of students' achievements. Online learning formats were conducted in Second Life (SL) technology for one semester by three groups (classes), and the data was collected, including several categories, i.e., project work, interaction logs, feedback forms, online quizzes, and attendance. We then employed the robust Multiple Linear Regression (MLR) technique to classify student performance during their virtual learning experience. The results showed significant improvements in student learning across several categories, with substantial variations observed among the different classes. Interestingly, we also found that students in each class had unique experiences and faced distinct challenges in the virtual learning environment.

1. Introduction

The COVID-19 outbreak has affected education systems worldwide, and different approaches and strategies are consolidated around concepts and theories to support education and keep it going. This has led to a surge in online learning and has highlighted the importance of e-learning in providing flexible, accessible, and high-quality education. E-learning, or online learning, uses electronic technologies to provide educational content and facilitate learning. It has become increasingly popular over the years, especially with the proliferation of the internet and mobile technologies, making educational materials more accessible anywhere and anytime.

Moreover, online learning is delivered entirely through electronic means, such as online courses, webinars, and doing tasks. It is a broad term encompassing various forms of digital education, including synchronous and asynchronous delivery methods [1]. Students can access course materials online, allowing for flexible and remote

learning. Online learning can also supplement traditional classroom learning, providing students with additional resources and opportunities to reinforce their understanding of course content [2].

One of the main advantages of online learning is its flexibility. is its flexibility, which allows students to schedule their studies around their current commitments, such as work or family responsibilities. Online learning is more cost-effective than classroom learning because it eliminates travel and reduces the need for physical space [3]. Overall, e-learning is an increasingly popular and effective way of delivering educational content and is likely to continue growing in popularity in the years to come.

Several studies have investigated the effects of online learning on student performance [3]. The results vary depending on context and methodology. A study by the U.S. Department of Education revealed that students who completed some or all of their coursework online tended to achieve better academic results than those who undertook the same course through traditional face-to-face instruction [4]. Furthermore, the study indicated that a blended learning approach combining online and face-to-face instruction was more effective than either fully online or fully face-to-face instruction. Moreover, a study conducted in Malaysia found that e-learning positively impacted the academic performance of university students, with the effect being more pronounced for students in higher-level courses. The study also found that using multimedia and interactive elements in e-learning was associated with better performance. While e-learning has many benefits, several studies also reported that several challenges must be addressed to ensure its success [5]. Gerdes et al. found the Lack of social interaction in e-learning. Student learning in e-learning can be isolating, mainly if it is conducted entirely online. Learners may miss the social interaction and support that comes with classroom learning, which can impact their engagement and motivation [6].

In addition, several previous studies noted that online learning or e-learning requires high self-motivation and management skills [3]. Teachers or instructors must be able to set goals, manage their creativity, and ensure that students stay focused on their studies, which can be challenging for some teachers. Besides that, interactive and exciting content on the learner process can be more challenging online than in-classroom learning. Providing interactive content can be difficult, mainly if learning uses Zoom, Meet, Webex, etc. [7]. Therefore, to address those challenges, the online learning or e-learning approach should be designed with considerations such as fostering social interaction, community building, offering interactive content, and gamification [8].

On the other hand, virtual worlds have become popular teaching and learning tools in recent years [9]. Virtual worlds offer an immersive and interactive gamified environment that allows learners to engage with content and activities in a manner that resembles real-life experiences more than traditional e-learning methods [10][11][12]. One of the primary advantages of virtual environments for online education is that they offer a secure and supervised space for learners to experiment, explore, and develop skills without real-world repercussions. For example, learners can practice communication skills, teamwork, and problem-solving in a simulated environment that closely mimics real-life scenarios [12][13]. Another benefit of using virtual worlds for online learning is that they can be used to create engaging and interactive learning experiences. Learners can explore virtual environments, interact with objects and characters, and participate in activities that promote active learning and knowledge retention [14]. Virtual worlds can also overcome some of the limitations of traditional e-learning approaches. For example, they can provide experiential learning opportunities that are difficult or impossible to replicate in real life, such as exploring the inside of a cell or traveling back to a historical event [11][13].

Online learning in virtual worlds can be used to track students' movement and navigation, providing insights into their problem-solving skills, spatial reasoning abilities, and decision-making processes [10][8]. Observing communication in virtual worlds can help educators identify patterns in students' communication skills, such as collaboration and expressing ideas. Several previous research also found that learning using a virtual world could be combined with social interactive learning or collaborative learning environments, attracting a large number of student users, eliciting the positive attitudes of students, and promoting students' cognitive and non-cognitive learning abilities [27]. In addition, Virtual worlds can also assess embodiment, revealing information about student's emotional regulation, self-efficacy, and empathy. However, most of the presented above have been intended to promote social interactive learning in the metaverse. The immersive metaverse can bring several advantages to higher education; it provides an alternative resource for supporting learning and teaching, making educational resources affordable.

Besides that, numerous studies have examined the impact of virtual world learning on student out comes in educational technology. However, research on effectively adapting relevant learning and motivational theories for designing sustainable pedagogy in complex and multifaceted virtual world learning environments remains relatively scarce. Additionally, immersive and interactive learning experiences are provided by metaverse technology, it is essential to comprehend how these experiences affect students' motivation, engagement, and subsequent academic success [26]. This is based on different study variables such as countries, objectives established in the documents, research methodologies carried out, participants, variables analyzed, and instruments used, so the results obtained are also different [26-27]. Whereas, virtual worlds offer opportunities for monitoring student engagement and motivation by observing their behavior, such as exploration, interaction, and persistence. So, virtual worlds provide a unique and valuable tool for formative assessment, allowing

educators to gather data on students' learning in real time and provide targeted feedback that can improve their learning outcomes [9][12][26].

Therefore, this research aims to investigate the influence of the virtual world of Second Life on student engagement. The study seeks to measure the impact of student participation in Second Life activities on academic results. The focus is on evaluating whether the use of Second Life as a learning tool enhances student engagement and subsequently leads to better academic outcomes.

The framework of scoping study includes three stages in total: (1) we implemented online learning in the virtual world (second life) as a programming subject in one semester for three classes (groups) to construct the effects of the virtual world approach in learning environments; (2)we observe by collecting data on the online learning activities to identify student skill patterns; and (3) we analyze student performance by classifying students' grades as they complete tasks and online learning activities, intending to know the impact of online learning in the virtual world.

2. Related Work

2.1 Virtual World in the Online Learning Approach

Virtual worlds have become increasingly popular as a tool for online learning. A virtual world is a computer-generated environment that enables users to interact with digital objects, avatars, and other users in a three-dimensional space [15][8]. Virtual worlds offer immersive online experiences that encourage collaboration. Several studies have shown that virtual worlds can improve learners' engagement, motivation, and learning outcomes [16]. There is a broad interest in adopting virtual world as solutions to support engagement in production with learning purposes, such as employees handling tedious tasks or programmers learning specific technologies [17][12][8]. This interest is also evidenced by the availability of hundreds of virtual development platforms offering pre-packaged templates to build gameful applications and commercial learning management systems aiming to improve educational and training experiences. Learning may be enhanced through gamification or games, which incentivize the process. For distance education, social VR platforms are trustworthy solutions enabling virtual methodologies [13].

Various virtual-based online learning techniques have been employed in informal education. In recent year, the focus shifted to more interactive forms of learning (e.g., online games). Using gamification features in training has become more common as technology has become more accessible and affordable [13][17-18]. They found that using virtual worlds in an online course significantly improved students' motivation, engagement, and learning outcomes compared to a traditional e-learning environment. In another study, virtual worlds have also been used in various educational contexts, including medical education, language learning, and science education. For instance, a study demonstrated that using virtual worlds to teach anatomy improved students' spatial ability and understanding of the subject matter [19].

Research conducted by Hedrick et al. (2022) suggests that metaverse technology can provide students with immersive learning opportunities to interact with items, explore virtual settings, and participate in simulations or virtual experiments. This can lead to improved critical thinking, problem-solving, and cognitive engagement. Another study by Alawadhi et al. (2022) found that personalized and adaptable learning experiences are possible through metaverse technology. Saeed et al. (2019) and de Carvalho et al. (2022) have shed light on the practices and challenges of nomadic knowledge sharing, offering insights that can help understand how metaverse technology may impact student engagement and academic performance through enhanced knowledge-sharing practices.

Metaverse technology enables students to receive customized feedback, individualized training, and adaptable content in virtual environments that address their unique requirements and learning preferences, thus promoting engagement. Yang et al. (2022) noted that students can communicate with professors and peers virtually through metaverse technology. This social involvement can improve students' emotional investment and sense of belonging, encouraging collaboration, teamwork, and knowledge sharing. Numerous studies have examined the impact of VR learning on student outcomes in educational technology. However, research on effectively adapting relevant learning and motivational theories for designing sustainable pedagogy in complex and multifaceted online VR environments remains relatively scarce.

Moreover, virtual worlds are practical tools for distance education, allowing learners to engage in collaborative learning. Students can interact with their instructors and classmates in real-time, regardless of their physical location [18][19][27]. The results showed that virtual worlds can enhance the sense of community and social presence among learners in online courses. In summary, using virtual worlds in e-learning has been well-researched and has shown promising results in improving learners' engagement, motivation, and learning outcomes.

2.2 Multiple Linear Regression (MLR)

Multiple linear regression (MLR) is a statistical method that helps to establish the linear connection between a dependent variable (also known as the response variable) and two or more independent variables (also known as predictor variables). MLR assumes that the relationship between the dependent and independent variables is linear. This means that the change in the dependent variable is proportional to the change in the independent variables. In other words, MLR is a tool that can be used to predict a dependent variable's value based on the independent variables' values. In MLR, a group of predictor variables is used to estimate the value of a dependent variable [20][21].

The model is based on a linear equation that establishes a relationship between the dependent and independent variables. The coefficients of the equation denote the impact of each independent variable on the dependent variable. The model can be used to forecast the dependent variable based on the values of the independent variables. MLR is often used to predict student performance and analyze relationships between multiple variables. It can be applied in situations where various factors may affect the outcome of a dependent variable, and it helps identify the most significant independent variables that contribute to the outcome.

Many studies have been conducted on predicting student performance using MLR model. El Aissaoui, Ouafae, et al (2019) [22] conducted a study to predict student performance based on several factors, including the number of hours spent studying, attendance, and prior academic performance. The study found that the MLR model accurately predicted student performance. Similarly, a study by Yang, Stephen JH, et al (2018) [20], used MLR to predict academic success in blended calculus subject based on learning activities dataset. The study found that the MLR model had a high level of accuracy in predicting academic success. Additionally, a study by Puah, Shermain (2020)[21] compared the performance of MLR and artificial neural network models in predicting student academic performance. The study found that the MLR model had a higher level of accuracy in predicting student performance.

Multiple Linear Regression (MLR) can effectively predict student performance and determine the factors that lead to academic success. However, it is essential to note that MLR assumes a linear correlation between the dependent and independent variables, which may not always hold true in reality [20].

3. Data and Method

Experiments conducted in a virtual world platform based on Second Life (SL) involve designing learning environments that simulate real-world scenarios to increase student engagement and learning outcomes over one semester. The participants were university students from fifth-semester classes in a programming computer subject at Universitas Negeri Medan, Indonesia.

Moreover, in virtual learning, where students may have different experiences and challenges, comparing a student's performance with multiple classes can be beneficial in assessing their overall performance and help identify potential areas for improvement [23][28]. Therefore, we experimented with three different classes (groups), named the A501 group, the A502 group, and the A503 group.

Researching the impact of different online learning elements on students' learning in the virtual world is essential. However, it is essential to narrow down the objective and focus on identifying the most effective learning elements for specific students engaged in a particular activity. This approach will help improve students' learning outcomes [24]. In this study, we aimed to study whether the virtual world affects students differently depending on their activity traits. We specifically aimed to collect data and investigate as follows:

Project work: We observed students learning in virtual world environments as they completed projects, taking data on how they approached the project, their level of engagement, and the quality of their work.

Feedback Forms: We gave feedback forms to evaluate their own work or their peers' work. That can include rating the quality of the multimedia and programming project, providing comments on specific areas, and identifying areas for improvement.

Online Quizzes: The online quizzes we used to collect data on student understanding of concepts content, such as syntax, algorithms, and multimedia. Quizzes are designed to provide immediate feedback, allowing students to review and reinforce their learning, as shown in Figure 1.

Attendance: The attendance was used to assess student learning outcomes to provide information on the student's engagement and participation in the course, although it does not directly measure their knowledge or understanding of the material.

Furthermore, we also considered the final grade of each student obtained from the Department of Computer Science, Universitas Negeri Medan as shown in Figure 2. Using a combination of the learning data in the virtual world and student final grade (s-Grades), we next predict how students behaved and progressed within the virtual world environments, therefore gaining more profound insights about the whole learning process, unlike questionnaires or interviews only.

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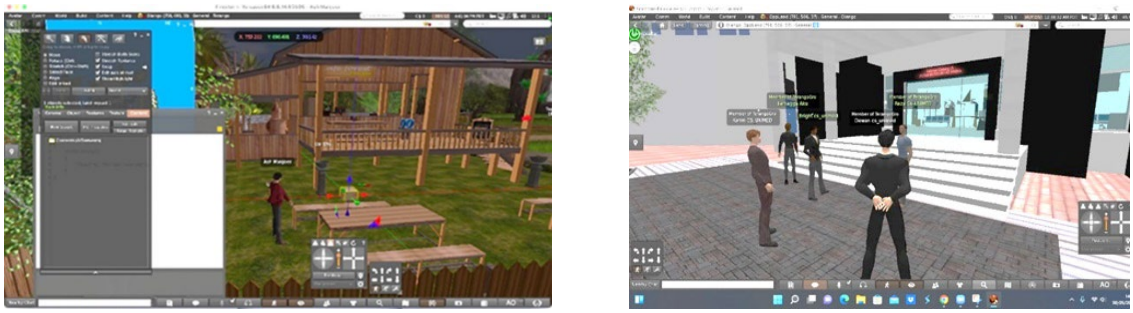

(a) **(b)**

Fig. 1 *Learning environment in second life (a) The student is creating three-dimensional objects using Linden Script Language (LSL); (b) Several students with their avatars discussing the course*

Figure 1 shows that we began by collecting data on several performance or component metrics related to student learning in the virtual world. The student engagement (component) data in virtual learning, i.e., project work, interaction logs, feedback forms, online quizzes, and attendance, was used as the independent variable (predictor). In contrast, the student's final grade data was used as the dependent variable (to be predicted). All parameters are assumed to be continuous variables. Then, the Multiple Linear Regression (MLR) was used to predict the relationship between a dependent and several independent variables.

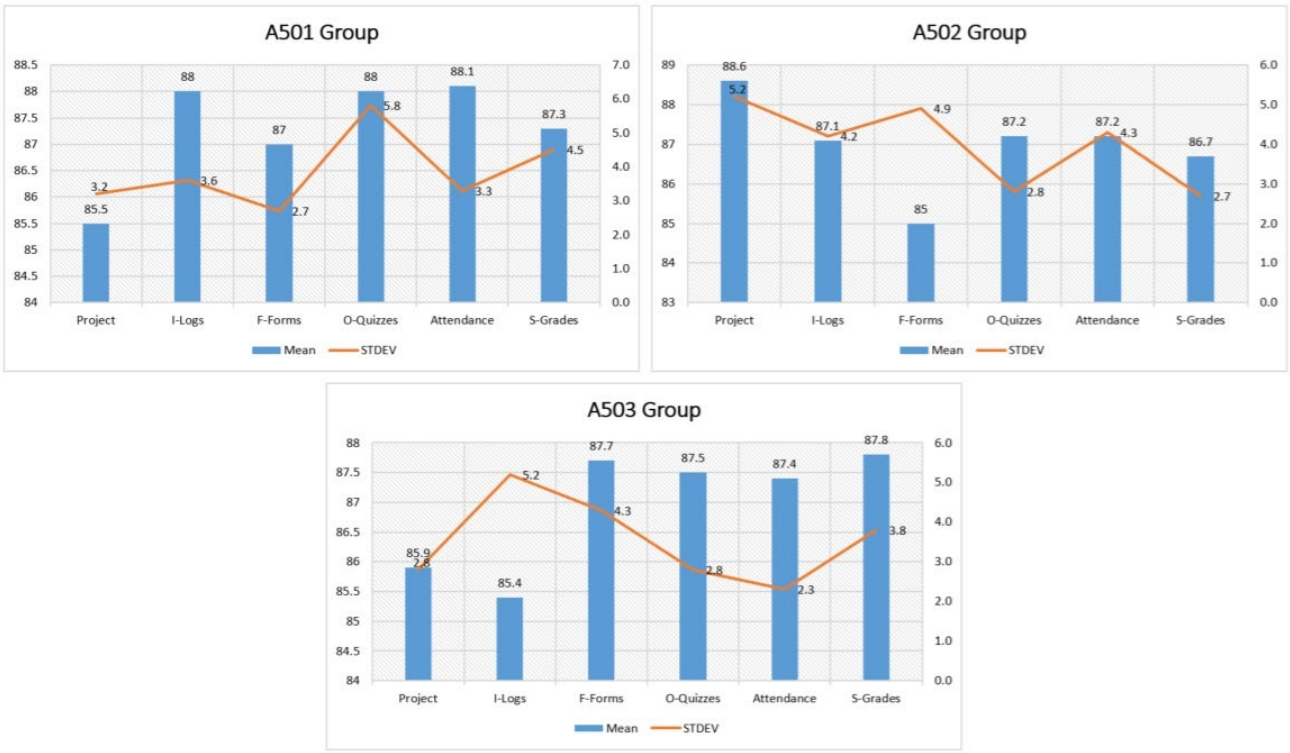

Fig. 2 *Summary of the three groups dataset*

Figure 2 presents the summary of the data. Each class has different mean grades for each component. In the A501 group, interaction logs, online quizzes and attendance components received higher grades than other component. In the A502 group, the project, interaction logs, online quizzes and attendance components obtained higher grades than other component. Similarly, in the A503 group, feedback form, online quizzes and components received higher grades than other component.

Apart from that, if we pay attention to the standard deviation values, there were significant differences in values for each component in each group. For instance, the online quizzes component in the A501 group had a standard deviation value of 5.8. In contrast, the project component in the A502 group had a standard deviation of 5.2, and the interaction logs component in the A503 group had a standard deviation of 5.2. Those data suggest that

students in different classes had different experiences and faced unique challenges in engaging with virtual learning.

4. Results and Discussion

4.1 Examining the Prediction Condition

Since the Multiple Linear Regression (MLR) method is used in this work, the set of actions considered was performed. In the first stage, we interpreted the ratio of variation in the independent variable that the set of predictors accounted. As shown in Table 1, the set of independent variables, i.e., project work, interaction logs, feedback forms, online quizzes, and attendance, accounted for approximately 34.5% - 35.2% of the variation in achievement for each group. Besides that, as suggested by Mizumoto, A. (2023) [25], for judging the size of the effect of the set of predictors, R2 => 0.26 is a significant effect. Therefore, using these standards, we examined the effect of the independent variable on the dependent variable, i.e., student grade in each group. We obtained results, i.e., in the A051 group is R2 =0.444 F= 4.473 P<0.004, in the A052 group is R2 =0.489 F=5.560 P<0.001 and A052 group is R2 =0.457 F=4.374 P<0.005 that means in each group the population R-square is more significant than zero. Those results indicate that the independent variables, i.e., components of student engagement in virtual learning can account for a significant amount of variance in student grades. So, in other words, the regression model is significant.

Table 1 *Ratio of variation in the independent variable*

Class	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.
A501	0.666	0.444	0.345	3.059	4.473	0.004
A502	0.7	0.489	0.401	2.775	5.56	0.001
A503	0.676	0.457	0.352	3.129	4.374	0.005

In addition, in MLR, the contribution of each predictor variable to the overall model can be examined by calculating the regression coefficients or beta weights. One unit increase in the predictor variable causes a corresponding change in the dependent variable equal to the coefficient. Therefore, it is essential to consider the statistical significance of each predictor variable's beta coefficient.

Table 2 *Regression coefficients*

Component	P-Value (sig.)		
	A501	A502	A503
Project work	0.002	0.017	0.046
Interaction Logs	0.038	0.038	0.018
Feedback Forms	0.003	0.000	0.174
Online Quizzes	0.000	0.447	0.000
Attendance	0.047	0.333	0.043

As shown in Table 2, all individual coefficients of the component, i.e., the project work, interaction logs, feedback forms, and online quizzes as independent variables for predicting student grades, obtained a p-value of less than 0.005 in each class. So that, at the 5% significance level, there is enough evidence to suggest a strong relationship between the component on student engagements in virtual learning (independent variable) and the student grades (dependent variable)," which means there is 95% confidence that the coefficient value falls in this range.

4.2 Student Performance

To accomplish the primary aim of this work, we reported ranking the overall performance of students, determined the impact of online learning in the virtual world, and determined how many students are relatively better.

First, we calculated the Average Prediction Accuracy (APA) using the following formula:

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$$APA\frac{n}{1}.\sum_{j=1}^{n}.\left|\frac{pj-aj}{aj}\right|x100 \quad (1)$$

where n is the total number of prediction results; pj is the predicted student grade score of all students in the class (j = 1 to n); and aj is the actual value of student grade score. The higher the average prediction accuracy, the better the model. Then, the percentage is calculated as the number of good predictions divided by the total number of prediction results. Using equation 1 above, we obtained the average prediction accuracy of the total classification results, which varies within only 3% with a minimum value of 55.3, and the percentage of good predictions varies within 97% with a minimum value of 78.5.

Based on the results above, we next classify the student grade using the Relative Score Index (RSI), as shown in Table 3. The RSI criterion divides the interval of the prediction result's minimum and maximum values.

Table 3 *Relative Score Index (RSI)*

RSI	Criteria	Level Performance
If student grade >85	A	Excellent
If student grade >75	B	Very Good Good
If student grade >65	C	Average
If student grade <65	D	

Table 4, shows the classification of students' performance based on the RSI values. The results show the number of students falling under each performance category for the A501 group. Out of the total number of students in this class, 14 students (42%) achieved excellent criteria, 10 students (30%) achieved Very Good criteria, 7 students (21%) achieved good criteria, and only two students (6%) achieved Average criteria. This outcome in the A501 group could be attributed to the significant impact of virtual programming courses on student performance. Next, in the A502 group, Excellent criteria were obtained by 12 students (34%), Very Good criteria were obtained by 12 students (34%), Good criteria were obtained by 8 students (23%), and Average criteria were obtained by 3 students (9%) respectively. Then, in the A503 group, Excellent criteria were obtained by 8 students (24%), Very Good criteria were obtained by 14 students (41%), Good criteria were obtained by 11 students (32%), and Average criteria were obtained by 1 student (3%) respectively. In the A502 and A503 groups, the Excellent criteria tended to decrease. From those results, we argue that students in different classes have different experiences and face unique challenges when engaging with virtual learning [28].

Table 4 *Student performance*

Categories	Percentage in each class (%)		
	A501	A502	A503
Excellent	0.42	0.34	0.24
Very Good	0.30	0.34	0.41
Good	0.21	0.23	0.32
Average	0.06	0.09	0.03

5. Conclusion

Identifying the factors influencing students' academic performance is exciting as it helps educators improve their online learning and teaching methods. To this end, we have proposed an online learning model in the virtual world and evaluated students' performance based on their participation and activity in the online learning process. Our methodology uses a new approach to support students' academic performance through a virtual world platform, i.e., Second Life. The results we obtained showed a significant influence on improving student learning in several categories and varied quite a lot in each class. We also found that students in different classes had different experiences and faced unique challenges in engaging with virtual learning.

In addition, this work is limited in that it uses only several categories and focuses only on one subject. Therefore, future research will use more complex scenarios to identify the factors influencing student online learning performance. It is essential to ensure that the analysis has enough precision or power.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

*Mansur As and Mario Köppen conceived of the **presented idea**. Mansur As developed the theory and carried out the **experiments**. Tsunenori Mine verified the **analytical methods**. Fauziyah Harahap encouraged Sitti Subaedah **collected data and investigate** the impact of online learning on students and **supervised the findings** of this work. Tsunenori Mine also contributed to the **interpretation of the results**. All authors provided critical feedback and helped shape the research, analysis, and manuscript.*

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