





BLENDED LEARNING MODEL INTEGRATED WITH QR CODE: IMPROVING STUDENT LEARNING OUTCOMES IN MATRIX ALGEBRANurul Farida¹, Nego Linuhung^{2,*}, Yuni Suryaningsih³, Nurain Suryadinata⁴¹ Universitas Muhammadiyah Metro, Lampung, Indonesia² Universitas Muhammadiyah Metro, Metro, Indonesia³ Universitas Lambung Mangkurat, Kalimantan Selatan, Indonesia⁴ Universitas Lampung, Lampung, IndonesiaCorresponding author email: nego.linuhung@ummetro.ac.id**Article Info**

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Abstract

Technological advancement is now a part of everyday human existence. A good example of this is the field of education. It is now widely understood that learning must be adaptable and accessible at all times in order to meet the needs of diverse learners. This level of flexibility is provided by the Blended instruction paradigm, which mixes in-person and online instruction. This study aims to determine the effect of the blended learning model assisted by QR codes on student learning outcomes in the Matrix Algebra course. The study took a quantitative approach and used a quasi-experimental design with one group pretest-posttest. The study included 34 Mathematics Education Program students from Universitas Muhammadiyah Metro in Indonesia. The researchers created and administered a series of verified and reliable (0.86) test instruments to the students, then evaluated the results with a paired sample t-test. Based on the findings, it is possible to conclude that implementing the blended learning approach with QR codes had a considerable favorable impact on students' academic progress in the Matrix Algebra course. This research innovatively proposes a blended learning framework involving qualitative data and advanced theoretical mathematics with the use of QR codes. The research shows that a blended learning framework with integrated QR codes can be effective and useful in improving university students' conceptual understanding and learning outcomes in mathematics courses.

Keywords: Academic Writing, Blended Learning, Genre-Based Approach, Higher Education, Technology.



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INTRODUCTION

In the era of artificial intelligence and digital transformation, technological advancements are inseparable from human life. This makes innovations, particularly in educational technologies, imperative. With tech in education, the impacts on student performances are improved ease and accessibility (Murad et al., 2019; Kurniawan et al., 2022; Zhang, 2022). Moreover, it facilitates access to

a wide range of learning resources, enabling students to explore topics more deeply and at their own pace (Haleem et al., 2022; Adeshina, 2024; Ahmad, 2024; Tanti et al., 2025). This approach also supports the development of digital literacy, which is crucial for success in the evolving job market.

Nowadays, learning is not only carried out in the classroom. Learning demands flexibility so that it can occur anywhere and anytime (Houlden & Veletsianos, 2019; Jonker et al., 2020; Tanti et al., 2020). Moreover, materials can be easily accessed at a low cost. The type of learning that is widely used now is online learning, where there are many advantages to be gained from online learning. Online learning has a stronger influence on student learning achievement (Warganegara & Kosasih, 2021; Tanti et al., 2021; Santoso et al., 2023; Alarifi & Song, 2024). Furthermore, according to (Mutia & Leonard, 2013; Adrias et al., 2023; Riyadi & Sudiyatno, 2023), e-learning, often known as online learning, allows students to learn without relying solely on teachers. Online learning also gives students access to up-to-date and accurate knowledge without being tied to time or location. Students can learn from anywhere, anytime, thanks to the ease of access to online learning, as long as they have a sufficient internet connection. However, various factors can influence the success of online learning, such as the level of interaction between students and teachers, the quality and quantity of materials, and technical support (Nambiar, 2020; Tanti et al., 2021; Kedia & Mishra, 2023; Hu & Xiao, 2025).

Learning mathematics requires mastery of concepts such as creating formulas in mathematical materials, so sometimes there are still many obstacles to being able to carry out learning fully in online discussions. Irfan et al. (2020) explained that one of the obstacles that occurs is limitations in presenting material, especially in courses that contain a lot of mathematical equations and programming languages. These limitations often result in students struggling to fully understand complex concepts, as the absence of face-to-face interaction can hinder effective communication (Eklund & Isotalus, 2024). Additionally, the lack of hands-on practice or immediate feedback in online discussions may further impede the learning process (Fatoni et al., 2020; Mishra et al., 2020; Mansour, 2024).

This problem can also occur in matrix algebra courses. Matrix algebra is a study of linear algebra. Some universities combine matrix algebra and vector algebra in linear algebra courses, and some universities separate matrix algebra and vector algebra. In matrix algebra, students still have difficulty understanding and applying the concept of matrix algebra (Aminullah, 2020; Fallo et al., 2022; Maharaj & Ntuli, 2022; Wahyuni et al., 2025). Further explained by Bedregal-Alpaca et al. (2020), the problems that arise when learning matrix algebra occur at the required level of abstraction. According to Bedregal (Bedregal-Alpaca et al., 2020), basically, students grasp the logical sequence to conduct operations without problem unless the computation is enormous. However, when students are asked to analyze the facts, they are confused and offer incorrect ideas.

Thus, face-to-face learning is still needed if there are concepts that are not clear when explained online. The learning model that can be used to combine online and face-to-face learning is the Blended Learning model (Hrastinski, 2019; Singh et al., 2021; Oktaria et al., 2023). Blended Learning is learning that integrates aspects of traditional learning carried out face-to-face with a learning environment that uses an online format (Hermita et al., 2024; Niyomves et al., 2024; Premachandran, 2024). Blended learning in higher education combines integrated and distributed models, analyzed through a thematic approach (Istenič, 2024). The advantages of blended learning are: (1) boosting social engagement, communication, and cooperation, (2) flexibility and efficiency, (3) expanding reach and mobility, and (4) optimizing costs and time (Azizan, 2010). Furthermore, based on research conducted by Sari (2013) and Oktaviani & Arini (2021), blended learning has been shown to improve learner independence, critical thinking skills, and student learning outcomes.

QR code technology is an effective and innovative technique to facilitate the implementation of blended learning (Meng et al., 2023; Ehora et al., 2024). QR codes allow students to access a variety of digital content instantly, such as instructional films, learning activities, and online links (Celik, 2023; Yanis et al., 2023). QR codes encourage student autonomy and self-regulation by making information easily accessible to students. Additionally, the use of QR codes increases student engagement and interaction, which enhances the learning experience (AlNajdi, 2022; Paramita et al., 2024; Yunimunninggar & Fardhani, 2024). Additionally, QR codes increase efficiency, enable customized teaching, and provide the flexibility associated with Blended Learning. Lastly, the use of QR codes offers a seamless connection between digital and actual classrooms, which enhances the learning experience.

A study found that problem-based learning (PBL) with QR codes can improve student learning outcomes (Farida et al., 2019; Mkm & Usman, 2024; Maharani et al., 2025; Sukma et al., 2025). Furthermore, previous study has shown that including QR codes in learning increases student learning

outcomes (Saleh et al., 2018; Al-sababha, 2024; Dewiyani et al., 2024; Firozabad et al., 2024). QR codes enable students to swiftly evaluate their work while also enhancing their understanding of the topic under consideration. Other experts have not conducted significant research on the coupling of blended learning with QR codes, particularly in matrix algebra. Furthermore, the significance of this study derives from the need to develop unique learning approaches that solve students' conceptual challenges in matrix algebra while being adaptable and accessible in the digital age. As higher education adopts technology-enhanced learning environments, it is vital to examine learning models that effectively combine face-to-face interaction with organized digital support.

To solve this issue, the study used a blended learning strategy combined with QR code technology. QR codes were inserted in student worksheets to give students direct access to extra digital resources, including learning films and supplementary materials, while in-person meetings were used for clarification, discussion, and deeper conceptual development. This organized integration aimed to improve self-directed learning, engagement, and conceptual understanding. This study aims to determine the effect of the blended learning model assisted by QR codes on student learning outcomes in the Matrix Algebra course.

RESEARCH METHOD

This research is a quantitative study employing a quasi-experimental approach with a single-group pretest-posttest design. The study population comprised undergraduate students in the Mathematics Education Study Program at Muhammadiyah University of Metro, Indonesia. The sample consisted of 34 students taking the Matrix Algebra course during the academic year. The sampling strategy used was purposive sampling, as the selected classes met the criteria for receiving the Blended Learning intervention with QR codes. This approach was used to meet the desired objective, namely, to determine the impact of the Blended Learning model on student learning outcomes in the matrix algebra course. Table 1 presents the single-group pretest-posttest design.

Table 1. One Group Pretest - Posttest Design Research Design

Pretest	Treatment	Posttest
O ₁	X	O ₂

The research instrument was a matrix algebra achievement test administered as a pretest and posttest. The instrument was validated by matrix algebra experts from several universities in Lampung Province, Indonesia, to ensure content validity. Furthermore, the instrument was tested for reliability, resulting in a reliability coefficient of 0.86, indicating high reliability. Data were collected through testing techniques, namely administering a pretest and a posttest. The pretest was given prior to the application of the QR code-assisted blended learning model, and the posttest was given after the treatment to assess the student academic achievement.

Data were analyzed using descriptive and inferential statistics. Before testing the hypotheses, normality and homogeneity tests were conducted to verify that the data met the required assumptions. The hypothesis was evaluated using a paired sample t-test to see whether there was a significant effect of the integrated learning paradigm, helped by QR codes, on students' academic advancement, using SPSS software. The treatment was carried out on the SPADA (Online Learning System) platform at Universitas Muhammadiyah Metro, as part of the Ministry of Education, Culture, Research, and Technology's nationwide SPADA Indonesia program. QR codes were embedded on student worksheets to allow direct access to supplementary digital learning materials, such as instructional films and additional resources. This integrates online and face-to-face learning components.

RESULTS AND DISCUSSION

This research began by carrying out a pretest on students. Next, learning was carried out using the blended learning model assisted by QR codes using SPADA UM Metro in the matrix algebra course. After learning using the Blended Learning model with QR code, students are then given a final learning test or posttest. A recapitulation of student learning outcomes from the pretest and posttest can be seen in Table 2.

Table 2. Summary of student learning outcomes in the matrix algebra course

No.	Learning Outcomes	Mean	St. Dev
1	Pretest	21.50	8.65
2	Posttest	75.03	11.61
3	N-Gain	53.53	9.11

Based on Table 2, there is a substantial improvement in students' learning outcomes in the Matrix Algebra course after the implementation of the blended learning model assisted by QR codes. The mean pretest score was 21.50 (SD = 8.65), which increased significantly to 75.03 (SD = 11.61) in the posttest. The mean N-Gain of 53.53 (SD = 9.11) indicates a moderate improvement in learning achievement, suggesting that the applied learning model effectively enhanced students' understanding of matrix algebra concepts. Furthermore, based on the results of the normality test on the pretest, posttest, and N-Gain value data, with $DK = \{L|L > L_{0,05;n}\}$ In each group, the result was $L_{obs} \notin DK$. This means that the test decision in each group is that H_0 is accepted, so it can be concluded that the samples in each group come from a normally distributed population. A recapitulation of normality test results can be seen in Table 3.

Table 3. Summary of normality test results

Data	N	L_{count}	L_{table}	Result	Summary
Pretest	34	0.126	0.152	Accept H_0	Normal
Posttest	34	0.078	0.152	Accept H_0	Normal
N-Gain	34	0.137	0.152	Accept H_0	Normal

Based on Table 3, because $L_{count} < L_{table}$, it can be seen that the pretest, posttest, and N-Gain value data come from a normally distributed population. Furthermore, based on the results of the homogeneity test, a value of 2.76 was obtained, and a value of 3.841. Due to the $\chi^2_{obs} \notin DK$ value, the test decision for the homogeneity test was H_0 , which was accepted, so it was concluded that the data test results before and after treatment were homogeneous.

After the analysis requirements in the form of normality tests and homogeneity tests are met, hypothesis testing is carried out using paired sample t-tests. This test was used to test the difference in average student learning outcomes before and after treatment in the same group. Based on the calculation results, data analysis on the N-gain value using the t-test obtained a value $t_{count} = 34,251$ and $t_{table} = 1,645$, so it can be said that $t_{count} > t_{table}$. Thus, the test decision is to reject H_0 and accept H_1 . These findings suggest that there is a statistically significant difference between pretest and posttest scores. In other words, the implementation of the QR Code-assisted Blended Learning model has made significant changes to student learning outcomes. In addition, because this study only involves two measurements that are paired with each other in one group without comparison of other groups, further analysis in the form of a post hoc test is not necessary. Based on the overall test results, it can be emphasized that the QR Code-assisted Blended Learning model has a significant effect on improving student learning outcomes in the Matrix Algebra course.

The results of the analysis showed that the application of the QR Code-assisted Blended Learning model provided a significant improvement in learning outcomes. An average N-Gain score of 53.53 indicates a moderate to high improvement category, which indicates that the interventions provided not only result in statistical changes, but also have a substantive impact on student understanding. Thus, the model applied is not just a variation of learning methods, but functions as a strategy that expands access to learning, deepens understanding of concepts, and increases student involvement in learning matrix algebra. These results support the results of previous research, such as research by Syarif (2013), which stated that learning outcomes increased significantly when using the blended learning model. Furthermore, based on research by Ningsih & Jayanti (2016), student learning outcomes also experienced good achievements. The blended learning model combines the shortcomings of classical learning, such as the lack of a lecturer's time to explain the material, which is covered by online learning. Furthermore, in the learning process, student motivation increases.

As the results of the Syarif (2013) research show, students' learning motivation increased significantly due to the implementation of the blended learning model. Apart from that, the use of material presented using a QR code containing videos of learning material makes students more focused on

listening to the material given in groups consisting of 3 people in learning. If previously the explanation of the material was presented classically in front of the class, there would still be students who were sleepy or chatting, but with the Blended Learning model assisted by QR code, students are more focused on learning. Students also become more independent in learning. This is to research (Ningsih & Jayanti, 2016) that increased students' ability to learn independently before implementing the Blended Learning Strategy and after implementing the Blended Learning Strategy. Learning Independence before the research was 14.3%, while after cycle 3 of implementing the Blended Learning Strategy, it was 85.7%.

Before the start of face-to-face learning, the instructor uploads course materials using the SPADA platform. This allows students to download and access materials before class to save time and avoid disruptions due to poor internet connectivity during class. This way, class time that is only 100 minutes long can be used for more active learning. SPADA, in this instance, is also used in accordance with the principles of blended learning, which in this case is focused on accessibility and learning flexibility (Hrastinski, 2019; Singh et al., 2021).

In the process of learning, students are given worksheets that have embedded QR codes. These codes are linked to supplementary learning resources, such as videos and written resources. Using their mobile devices, students scan QR codes to access the resources and learn interactively (Aldeeb et al., 2024; Stefanova et al., 2024; Syskowski et al., 2024). Students are placed in small groups and are tasked to explore the resources and to collaboratively solve the given tasks, then discuss their answers. This particular approach to teaching increases student concentration and encourages learning from one another. This was the case in the study, where students displayed high levels of concentration and enthusiasm when learning from QR codes. While students are working on QR code activities, in case they have questions, the instructor provides immediate answers to guarantee that students grasp the concepts, most especially on the challenging topics (Ucak & Usta, 2022; Rakha, 2025), such as in matrix algebra (Bedregal-Alpaca et al., 2020).

Due to the time needed, not all questions or concepts can be explained during face-to-face sessions. Therefore, online discussions via SPADA are continued after class to accommodate further questions and provide additional explanations. Students submit open questions, while lecturers can give more comprehensive feedback asynchronously. This hybrid paradigm encourages students' individual learning and handles disparities in learning pace, which is critical in a math course that requires complicated thinking (Ningsih & Jayanti, 2016; Fatoni et al., 2020; Aristika et al., 2021).

As previously noted, pretests and posttests took place online, with results readily available. Notably, posttest scores exceeded pretest scores, with a mean N-Gain of 53.53 (Table 2) reflecting a moderate to high increase in learning outcomes. Participants demonstrated significant ($t_{\text{count}} = 34.251 > t_{\text{table}} = 1.645$) learning advancement. These findings confirm the effectiveness of the Blended Learning model with the support of QR codes. Similar conclusions have been drawn on the positive influence of blended learning on students' self-efficacy, participation, and performance (Oktaviani & Arini, 2021; Daniel et al., 2024; Liu et al., 2024; Shoukat et al., 2024).

A distinctive aspect of the current study is the purposeful deployment of QR codes across a blended learning approach designed specifically for university students learning matrix algebra. This study shows that this improvement is strengthened through the integration of QR Codes that directly connect students with structured learning resources, such as learning videos and supporting materials. Thus, the results of this study not only confirm the effectiveness of blended learning, but also show that simple technology optimization such as QR Codes can amplify its impact. Whereas previous studies have examined blended learning or QR codes in isolation, this study integrates both elements within a cohesive framework designed for high-level abstract mathematics. In terms of implementation, uploading materials through the SPADA platform before lectures allows students to do pre-learning, so that face-to-face time can be used for discussion and deepening of concepts. This strategy is in line with the principles of flexibility and accessibility in blended learning (Hrastinski, 2019; Singh et al., 2021). In addition, the use of worksheets integrated with QR Code encourages students to study collaboratively in small groups while still having independent learning opportunities. This condition contributes to increased concentration, active participation, and student learning independence.

More broadly, the results of this study reinforce the findings of various studies that state that blended learning has a positive impact on academic performance, self-efficacy, and student participation (Oktaviani & Arini, 2021; Daniel et al., 2024; Liu et al., 2024; Shoukat et al., 2024). However, the distinctive contribution of this research lies in the integrative design between the blended learning model and the systematic use of QR Code in the context of abstract mathematics learning in higher education,

especially in the Matrix Algebra course. Previous research generally examined blended learning or QR Code separately, while this study combines the two in one empirically tested learning design. The findings of this study indicate that lecturers in higher education can use QR code-assisted blended learning as a practical technique to improve student engagement, conceptual understanding, and academic success. Institutions need to develop adequate digital infrastructure to enable the adoption of technology-integrated learning pedagogy.

Nonetheless, this study has its limitations. A single-group pretest-posttest design without a control group weakens causal claims. Also, the small sample size and the fact that it was collected from only one institution, would limit the generalizability of the study. Further research should aim to incorporate control groups and experimental designs, as well as larger and more heterogeneous samples, and consider other variables like higher-order thinking, long-term retention, and student engagement. Practically, the results of this study imply that lecturers in higher education can utilize QR Code-assisted blended learning as an effective strategy to increase student engagement and conceptual understanding. The results of the study seem to suggest that a blended learning model with the use of QR codes has a positive impact on teaching and learning of mathematics in higher education. QR codes facilitate online learning content access and enable learners to study collaboratively or on an individual basis. Because class time is limited, learning materials are provided via QR codes to promote additional learning activities outside the classroom, as these codes link to pre-structured online learning materials. This approach is especially beneficial for students studying less concrete subjects, such as matrix algebra, as it provides them with the flexibility to engage with the material. With a systematic design, this approach has the potential to be applied to other courses that have a high level of abstraction.

CONCLUSION

Based on the results and discussion, it can be concluded that the use of the blended learning model with the integration of QR codes positively affects student learning outcomes in the course Matrix Algebra. This method demonstrated that student outcomes increased. Furthermore, it helped students comprehend abstract mathematics better. This method of learning promotes the ease of accessing content, learning independently, and collaborating in problem-solving, especially where the problem is abstract in mathematics. The quick access of the QR code to the learning materials enabled the students to save time, especially given the short duration of the class. However, the implementation of this method requires good and high-speed internet. In this way, the use of this method is suggested to be carried out in the form of assignments that can be downloaded from the SPADA platform to be available offline on student devices readily.

In addition, the results indicate that blended learning and QR code access in higher education are useful, especially in courses that require a high level of understanding of mathematical operations. Institutions should support adequate technological infrastructure to maximize the effectiveness of technology-integrated learning models. Future studies could include a bigger and more diverse population of institutions for the purposes of greater generality of results. For one, an investigation comparing the proposed system with other approaches like fully online education, inverted classes, and problem-based learning would certainly yield valuable results on relative effectiveness. Further studies could also be conducted to determine the effects of the proposed system on engagement, mastery of concepts, and higher-order thinking skills.

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AUTHOR CONTRIBUTIONS

Nurul Farida contributed to the conceptual development of the study, instrument construction, data collection, data analysis, and manuscript preparation. Nego Linuhung was responsible for drafting and revising the manuscript, interpreting the research findings, proofreading, and granting final approval of the submitted version. Nurain Suryadinata contributed to data interpretation and provided material support for the study.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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