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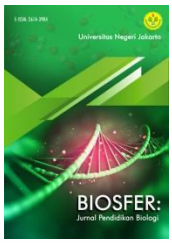

LMS - based blended learning to improve students' collaboration skills in biology learning

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ABSTRACT

This study aims to determine the effect of various types of blended learning (station rotation, lab rotation, and pedati) on collaboration skills. The research design used a quasi-experimental approach. The population in this study included all eighth-grade students at SMP Negeri 2 Sengkang, with the research sample consisting of classes VIII.1, VIII.2, VIII.3, and VIII.4. In the implementation, the experimental classes were taught using station rotation, lab rotation, and pedati types of blended learning, while the control classes were taught using STAD. The research instrument used a collaboration skills observation sheet based on five indicators: Responsibility, Respect, Contribution, Organize Work, and Work as a Whole Team. Data collection was conducted by an observer before and after the treatment. Data analysis techniques used Ancova with a significance level of 0.05. The results of the study indicate that there is an effect of blended learning types station rotation, lab rotation, and pedati on collaboration skills. Based on the LSD (Least Significant Difference) post-hoc test, the station rotation type of blended learning showed the highest average in collaboration skills compared to the other types. The findings of this study indicate that blended learning can be applied in classroom learning to support the development of students' collaborative skills in facing educational challenges in the digital era.

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INTRODUCTION

Education is a lifelong process that aims to create behavioral changes in the desired direction and develop individual talents, attitudes, and cognitive, affective, and psychomotor domains as a whole to be valuable in social life (Danso, 2018; Eryilmaz, 2021). Education is a process of fostering and developing knowledge, skills, values, and mental, social, and personal aspects of individuals through various models, which ultimately enables the achievement of sustainable development (Almuhaimeed, 2022; Su et al., 2022; Tutar & Serpil, 2024). Education is an important component in enhancing long term competitiveness, social stability, and human, economic, social and technological development, the results of which will be optimal if properly utilized and financed (Köprülü et al., 2022; Oladele et al., 2019). The educational process is based on three main components, namely teachers, students and the environment (Yüksel et al., 2023). The ultimate goal of education is to form individuals who are independent, adaptive, communicative, concerned about social values, and able to access and utilize technology and learning resources effectively (Gökyer & Cirit, 2018). The 21st century, characterized by technological advances and global connectedness, demands a shift in education towards a student-centered approach to equip individuals with relevant skills to cope with new learning methods (Çetingöz, 2023; Soylemez, 2023; Sihawong & Phusee-orn, 2023). The European Union recognizes eight key competencies for 21st century skills, one of which is collaboration skills (Cantaş et al., 2024). The 21st century is not enough for students to only have basic competencies such as reading and writing, but also need to master social skills by interacting well with others (Barkley et al., 2014).

However, empirical facts in the field show low collaboration skills (Hidayati et al., 2023; Le et al., 2018). The weak collaboration skills of students at school are shown by the low ability to work in groups, the lack of mutual respect for differences in opinion, as well as closed attitudes and not accommodating each other (Nahar et al., 2022). This is reinforced by (Le et al., 2018) who stated that students' lack of understanding of the collaborative learning process, as well as inability to accept different points of view, provide explanations, give and receive help, and negotiate, are the main obstacles in the effectiveness of group work. In addition, there is a free-riding phenomenon where when collaborating on group tasks, some friends contribute the most, while others work less, and some do not even try hard when completing their own tasks. A similar phenomenon was found by (Firman et al., 2023) where during group learning only one student explained while other students did not work. Collaboration between group members is still low, characterized by students who do not want to be burdened by the responsibilities of other students, besides that there are still some students who are less active and contribute less during class discussion activities. This condition further indicates the weak collaboration skills of students in learning. A number of studies illustrate that many children and young people are not good at building and maintaining relationships with their peers (Ghavifekr, 2020; Tikkanen et al., 2024) This phenomenon is reinforced by the statement of (Hidayati et al., 2023; Hartina et al., 2022) which states that collaboration skills are one of several skills that are still relatively poorly mastered in Indonesia.

Low collaboration skills are caused by various factors, one of which is not optimal teaching methods used by teachers (Le et al., 2018; Loughlin & Lindberg-Sand, 2023; Mu'arifah et al., 2023). Teachers still present material to students using the teacher-centered lecture method, making it less likely for students to work together and collaborate in learning activities (Nurmayasari et al., 2022). The lack of human resources in schools, including teachers who still use conventional approaches and rarely apply group work such as discussions, causes low student collaboration skills (Hamdani & Wardani, 2019; Khoiriyah et al., 2024). Thus, it can be said that one of the main causes of student failure is poor teaching. The traditional lecture teaching method is called passive because information is delivered orally to students and students are not actively involved at all. The result of passive teaching makes students passive learners (Diepreye & Odukoya, 2019). Passive learning activities involve a lack of observable physical activity (Sailer et al., 2021). As a solution to this problem, blended learning can be used as a learning alternative to help improve student interaction (Bouilheres et al., 2020; Dakhi et al., 2020). Blended learning is an online and offline style of learning that combines virtual learning and face-to-face learning in the classroom (Sun et al., 2024), where this learning system is implemented with time blocks (Adnan et al., 2016), not only as a hybrid teaching approach but as a strategic approach that utilizes online and face-to-face (Alkursheh, 2024). One of the e-learning platforms that has evolved in accordance with the development of information and communication technology is the Learning Management System (Vieyra & González, 2023). LMS is used to enhance all three modes of delivery which

include face-to-face, online, and blended learning (Turnbull et al., 2023). The ubiquity of LMS has facilitated the distance of teaching and learning process with all three delivery models (Brown et al., 2021). Discussion forums, chat rooms, and messaging allow students to interact with peers, fostering a sense of community, active engagement, teamwork, and knowledge sharing among students (Mphahlele et al., 2023). It gives more space for both teachers and students to strengthen learning (Bradley, 2021). The implementation of blended learning based on a learning management system improves students' collaboration skills by changing peer-to-peer interaction to be more collaborative, providing a sense of responsibility in learning, and increasing accessibility and interaction through a combination of face-to-face and online learning (Bersamin et al., 2024; Ellis et al., 2016; Salcedo, 2022). Globally, various studies have shown that digital learning technologies can have a positive impact on student learning engagement (Jamaluddin et al., 2025).

Blended learning has various types that can be applied in the learning process, such as station rotation, lab rotation, and pedati types (Adiwisastra et al., 2020; Kömür et al., 2023; Andika et al., 2025). To improve the quality of classroom learning and ensure that students are given the right support for their learning, it is important to understand how to effectively combine face-to-face and online learning. However, it is important to realize that each type of blended learning has its own set of advantages and disadvantages (Kömür et al., 2023). Research on blended learning has been conducted in various educational contexts. However, most existing studies only highlight one type of blended learning separately, such as station rotation or lab rotation, without making direct comparisons between different types. The novelty of this study lies in its attempt to directly compare three types of blended learning (station rotation, lab rotation, and pedati) in relation to improving students' collaboration skills. This comparative approach has not been widely used, so it is expected to provide new insights into the effectiveness of each type in the context of 21st-century learning. The urgency of this research is based on the low level of collaboration skills among students in Indonesia (Hidayati et al., 2023; Nahar et al., 2022). In fact, collaboration skills are one of the key competencies of the 21st century that are highly needed in both the world of education and the world of work. Therefore, a learning model that is able to facilitate students to interact, work together, and build knowledge collectively is needed. Blended learning based on LMS with its various types is believed to be a solution to this problem. Therefore, this study focuses on how the three types of blended learning affect students' collaboration skills. The research question in this study is whether there is an effect of learning management system- assisted blended learning on the collaboration skills of eighth-grade students at SMP Negeri 2 Sengkang.

METHODS

Research Design

This research is a true experimental research with the independent variable is blended learning, while the dependent variable is collaboration skills. In its implementation, this research used a pretest-posttest control group design (Campbell et al., 1963). The description of this research design is presented in Table 1.

Table 1.
Research Design

Group	Initial	Treatment	Final
Experiment I	O_1	X_1	O_2
Experiment II	O_3	X_2	O_4
Experiment III	O_5	X_3	O_6
Control	O_7	-	O_8

Keterangan:
X_1: Blended Learning Station Rotation Type
X_2: Blended Learning Lab Rotation Type
X_3: Blended Learning Pedati Type
- : Student Team Achievement Division (STAD)
O_1: Initial Value of Experimental Class I
O_2: Final Grade of Experimental Class I
O_3: Initial Value of Experimental Class II
O_4: Final Grade of Experimental Class II

O_5: Initial Value of Experimental Class III
O_6: Final Grade of Experimental Class III
O_7: Initial Value of control class
O_8: Final Grade of control class

Population and Samples

The population in this study was all VIII-grade students of SMP Negeri 2 Sengkang, which amounted to 227 students and was divided into 7 classes. The research sample was selected using a simple random sampling technique, so that 128 students were obtained from 4 classes, where class VIII.1 was the control class that applied student team achievement division learning, and VIII.2, VIII.3, and VIII.4 as the experimental class respectively applied blended learning type station rotation, lab rotation, and pedati. Each class has 32 students each. The population and sample of this study can be seen in Table 2.

Table 2.
Population and Sample

Class		Number of Students
Population	VIII.1	32
	VIII.2	32
	VIII.3	32
	VIII.4	32
	VIII.5	32
	VIII.6	32
	VIII.7	32
Total		**227**
Sample	VIII.1	32
	VIII.2	32
	VIII.3	32
	VIII.4	32
Total		**128**

Instrument

The data in this study are student collaboration skills data collected using an observation sheet instrument filled in by the observer before treatment and after treatment. The research parameter used is collaboration skills with five indicators, namely Responsibility, Respect, Contribution, Organize Work, and Work as a Whole Team (Hidayati et al., 2023). To ensure clarity and validity, the instrument was tested by two academic experts who provided feedback and input. The type of validity used is content validity (expert judgment). The results of the questionnaire validity are presented in Table 3.

Table 3.
Validity of collaboration skills observation sheet

Assesment Aspect	Assessment Score	Category
Format	5.00	Very valid
Contents / Collaboration Indicators	4.60	Very valid
Languange	4.25	Very valid
Average	4.61	Very valid

Procedure

The research procedure begins with (1) the preparation stage, including literature review, formulation of problems and hypotheses, preparation of research instruments, and learning tools such as designing an LMS that will be used by students during the learning process, as well as validation of instruments and learning tools by 2 expert lecturers. (2) Implementation stage, including: a) conducting initial observations to assess collaboration skills in experimental and control classes before the intervention, b) providing interventions in each class, where the experimental class is given the treatment of blended learning type station rotation, lab rotation, and pedati, and the control class is given the treatment of student team achievement division. c) Every meeting was observed in both groups to measure how collaboration skills improved after the intervention was applied to determine

the impact of the treatment given. (3) The final stage involves analyzing the research data and drawing conclusions. The research procedure can be seen in Figure 1.

Figure 1. Research Procedure

As an illustration, the steps of each type of blended learning used in the implementation of this research can be seen in Figure 2 below, which uses station rotation. The learning steps in blended learning type station rotation consist of 3 stations, including: (1) Online Instruction, where students explore (read, listen, observe) all learning online, either through LMS or other online features. (2) Collaborative activities and stations where students collaborate and discuss directly with their groupmates to work on worksheets that have been given by the teacher related to learning materials. (3) Teacher Lead Instructions, which is the stage of strengthening learning material by the teacher, and students can ask the teacher if there are things that are not understood. Then the learning ends with giving a quiz in the form of multiple-choice tests that are done online on the LMS platform.

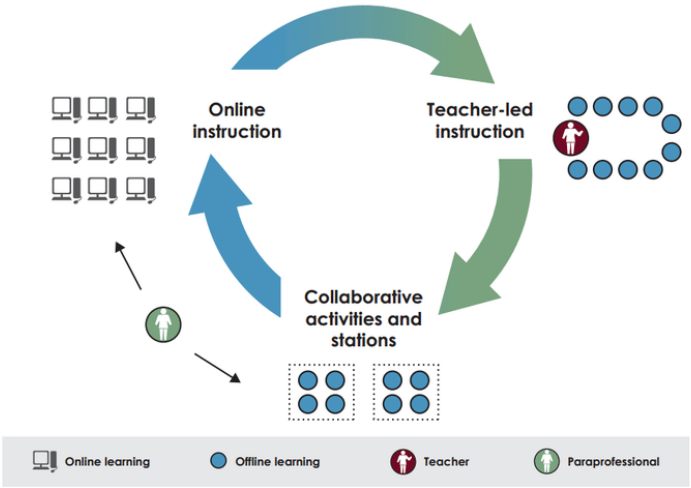

Figure 2. Blended Learning Station Rotation Type (Staker & Horn, 2012)

The learning steps of the second type of blended learning, the lab rotation type, can be seen in Figure 3. The learning steps in the lab rotation model are executed by: (1) students spend a part of their learning in the room for online learning. In this process, students can work flexibly at their own pace, spending as much time as they need to understand the material. A teacher can also group students into several small groups. At this stage, the activities include online exploration of materials either through the LMS or through other online features, followed by online discussion of questions posed by the teacher through the LMS platform, and ending with assignments on the LMS, a feature to access assignments online. (2) Then, after the learning in the online room has been completed, students can rotate to classroom learning with the guidance of the teacher. On this occasion, students who have learned the basic material in online learning can deepen their understanding and ask questions related to complicated concepts during face-to-face learning. Furthermore, the learning is ended by giving a quiz in the form of multiple-choice tests that are done online in the LMS platform.

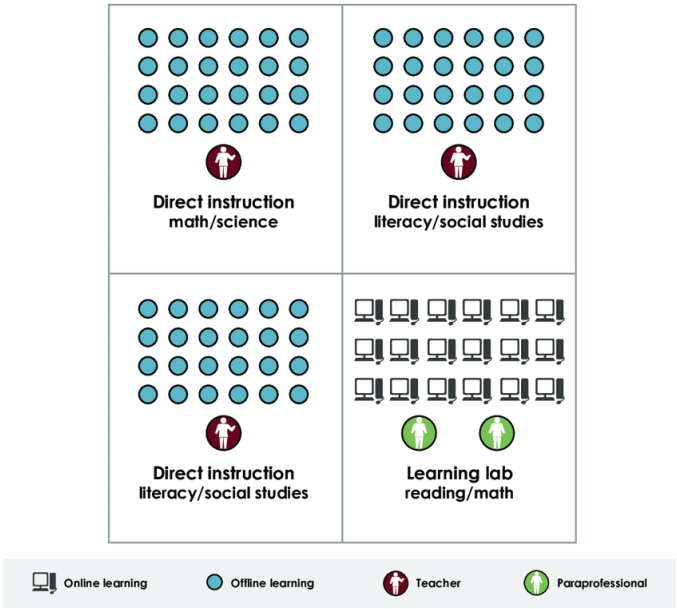

Figure 3. Blended Learning Lab Rotation Type (Staker & Horn, 2012)

Then the learning steps of the third type, namely Blended Learning Pedati Type, can be seen in Figure 4. The learning steps in the pedati type of blended learning consist of: (1) Learning, carried out offline, where students learn the material either through textbooks and hear the teacher's explanation. (2) Deepening, carried out online, where students do activities through online discussion forums on the LMS. (3) Applying where students do the tasks given by the teacher offline. (4) Evaluate learning, which ends with giving a quiz in the form of a multiple-choice test, which is done online on the LMS platform.

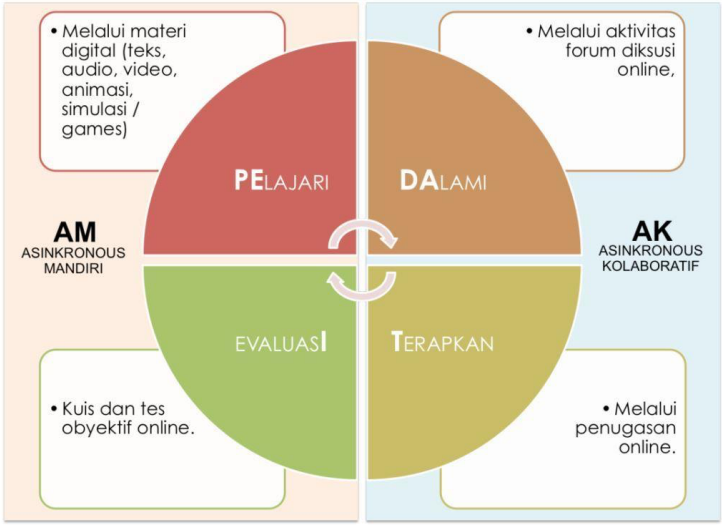

Figure 4. Blended Learning Pedati Type (Chaeruman, 2018)

To support the implementation of blended learning, a learning management system (LMS) is utilized as the main media in implementing online-based learning. Through the LMS, students can explore materials, discuss online, submit assignments, and take part in learning evaluations. The following figure presents the LMS used in station rotation, lab rotation, and pedati type blended learning.

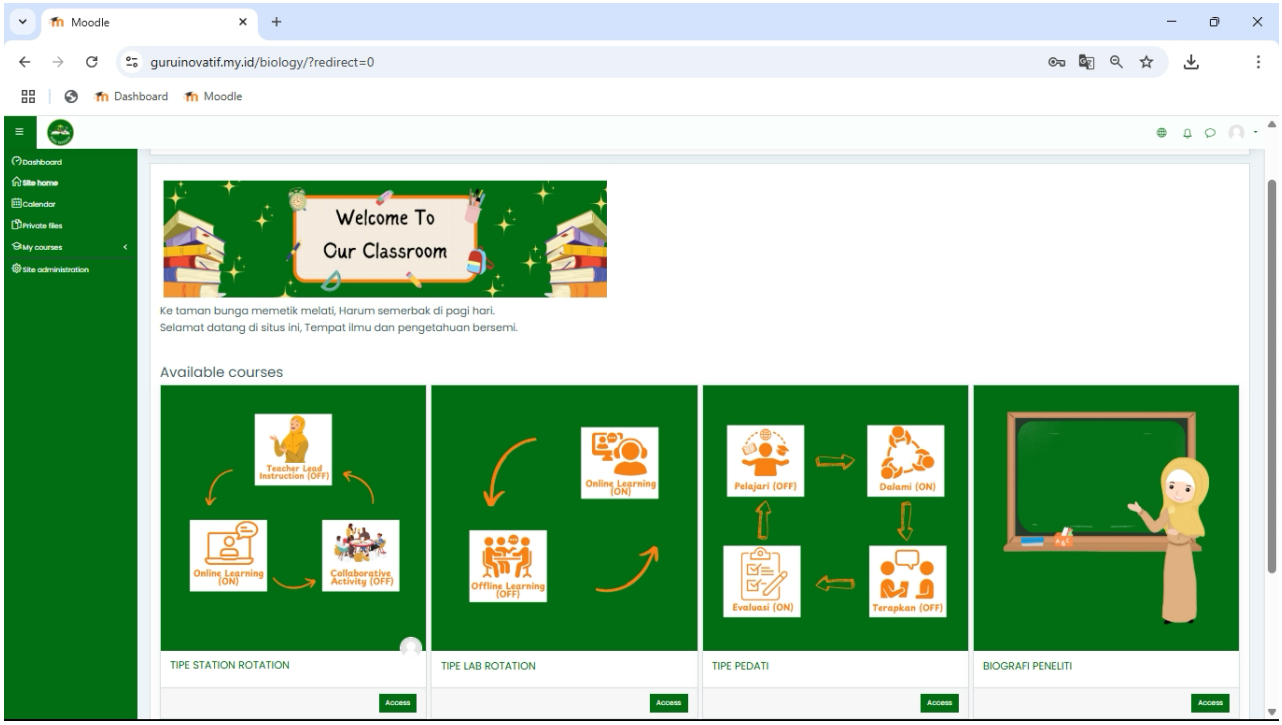

Figure 5. Learning Management System

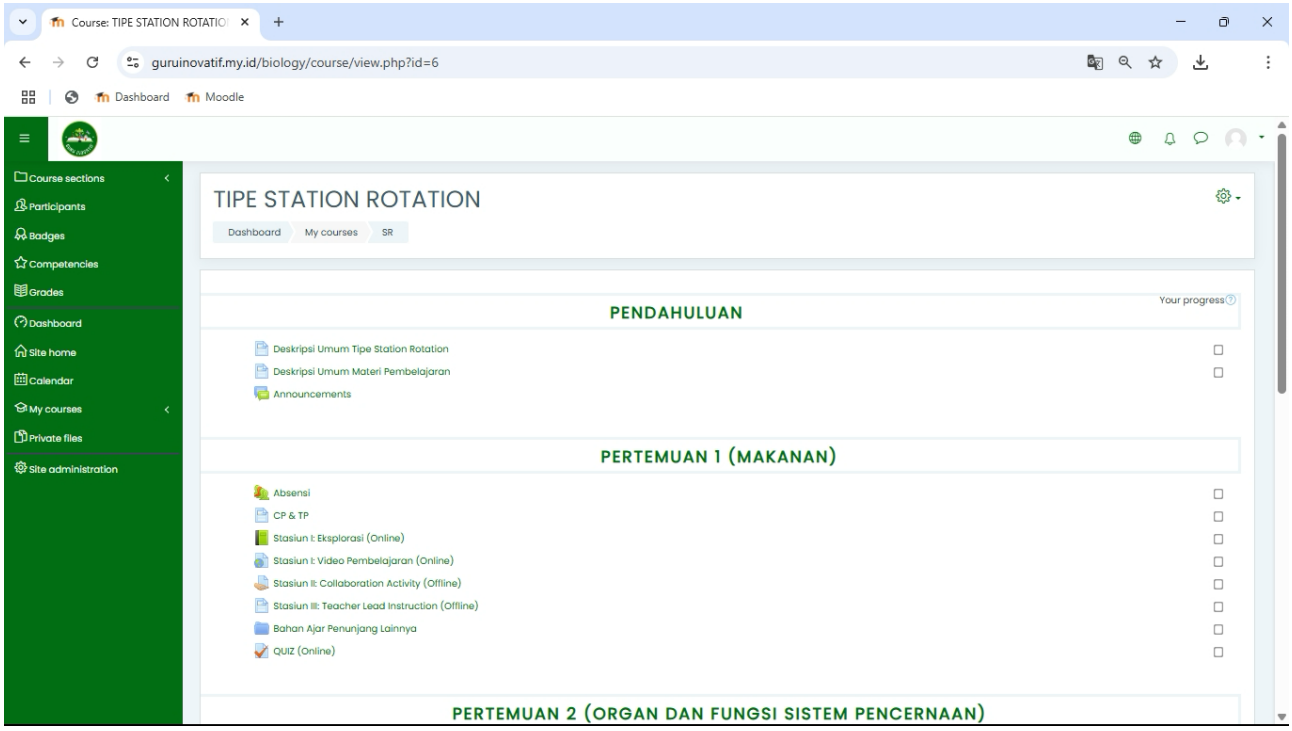

Figure 6. Learning Management System Menu

Data Analysis Techniques

Data analysis techniques were performed through prerequisite tests that included normality and homogeneity tests with a significance value above 0.05 to ensure that the data met statistical assumptions. Normality was tested using Kolmogorov-Smirnov, while homogeneity was tested using Levene's Test. All of these prerequisite analyses were processed using SPSS version 27 so that the results obtained were more objective and accurate. After the data were found to be normally distributed and homogeneous, hypothesis testing was conducted using the ANCOVA (Analysis of Covariance) test with a significance level above 0.05 to test the differences among various types of blended learning. If the ANCOVA result shows that there is a difference among various types of blended learning, then a further test is conducted using LSD (Least Significant Difference) to identify the type of blended learning that has the most influence on collaboration skills. The results of normality and homogeneity tests can be seen in Tables 4 and 5.

Table 4.
Kolmogorov-Smirnov Normality Test

Collaboration Skills	Control Class	Experiment Class			Description
	STAD	Station Rotation	Lab Rotation	Pedati	
Initial	.118	.127	.200	.125	Normal
Final	.200	.200	.192	.200	Normal

Table 5.
Levene's Homogeneity Test

Collaboration Skills	Sig.	Description
Initial	.638	Homogeneous
Final	.139	Homogeneous

Based on Table 4, the Kolmogorov-Smirnov normality test results show that all data, both before and after treatment, have a significance value > 0.05. Thus, the data is normally distributed. After the normality test, the homogeneity test was conducted using the Levene method to check the similarity of variance between groups. Then, Table 5 shows the results of Levene's homogeneity test, indicating that all data, both before and after treatment, have a significance value > 0.05, meaning that the data have homogeneous variance.

RESULTS AND DISCUSSION

The research data were obtained from the observation of the initial and final collaboration skills of the experimental and control groups. Table 6 presents a recapitulation of the results in descriptive statistics. The results in Table 6 show that station rotation blended learning had the highest effect on students' collaboration skills compared to other types. This can be seen from the final average score of the station rotation group, which was 84.01, higher than STAD (77.94), lab rotation (81.24), and pedati (81.97). The maximum score achieved by students in station rotation also reached 90.00, indicating optimal collaboration in this group. This finding is in line with Vygotsky's theory of social constructivism, which emphasizes the importance of social interaction in constructing knowledge. Previous research by Akinoso et al. (2020; Harb, 2019) confirmed that station rotation is effective in encouraging collaboration among students because it provides them with more opportunities to engage in various learning activities through interaction with their peers.

Table 6.
Descriptive Analysis of Collaboration Skills

Collaboration Skills	Descriptive	Control Class	Experiment Class		
		STAD	Station Rotation	Lab Rotation	Pedati
Initial	N	32.00	32.00	32.00	32.00
	Max	64.00	64.00	66.00	64.00
	Min	44.00	42.00	42.00	46.00
	Mean	56.06	56.25	55.56	56.68
	SD	5.43	5.44	5.96	4.83
Final	N	32.00	32.00	32.00	32.00
	Max	85.33	90.00	88.00	90.00

Collaboration Skills	Descriptive	Control Class	Experiment Class		
		STAD	Station Rotation	Lab Rotation	Pedati
	Min	69.33	75.33	70.66	70.66
	Mean	77.94	84.01	81.24	81.97
	SD	4.97	3.47	5.04	5.27

Table 7 shows that the results of the Ancova test on learning type with the value of F = 12.075 with sig value of 0.001 <0.05 (significance value is less than 0.05), then H0 is rejected and H1 is accepted. Thus, it can be concluded that there is a difference among the 4 types of learning in the collaboration skills score of students in class VIII of SMP Negeri 2 Sengkang.

Table 7.
Ancova Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1411.363[a]	4	352.841	21.774	.001
Intercept	3488.105	1	3488.105	215.250	.001
Before Treatment	800.095	1	800.095	49.374	.001
Learning Type	586.999	3	195.666	12.075	.001
Error	1993.201	123	16.205		
Total	849366.838	128			
Corrected Total	3404.564	127			

If there is a difference in the results of Ancova analysis on collaboration skills, the analysis is continued with the LSD (Least Significant Difference) test to determine the learning model that has the most influence on students' collaboration skills. The results of further testing with the LSD test with a significant level of 0.05 can be seen in Table 8.

Table 8.
Least Significant Difference (LSD) Test Results

Variables	Class	Mean Difference	Sig.	Testing	Description
Collaboration Skills	Station Rotation and Lab Rotation	2.449*	.017	Sig < 0,05	Significant
	Station Rotation and Pedati	2.246*	.027	Sig < 0,05	Significant
	Lab Rotation and Pedati	-0,202	.841	Sig > 0,05	Not Significant
	Station Rotation and STAD	5.985*	.001	Sig < 0,05	Significant
	Lab Rotation and STAD	3.536*	.001	Sig < 0,05	Significant
	Pedati and STAD	3.739*	.001	Sig < 0,05	Significant

Table 8 LSD test results show that all comparisons have significance values below 0.05, namely in blended learning of station rotation with lab rotation (0.017), station rotation with pedati (0.027), station rotation with STAD (0.001), lab rotation with STAD (0.001), and pedati with STAD (0.001), except for the comparison between BL lab rotation and BL pedati, which has a significance value of 0.841 > 0.05. This indicates that there is no significant difference between BL lab rotation and BL pedati, meaning that these two types have no significant effect on students' collaboration skills. Meanwhile, all other comparisons have significance values less than 0.05, indicating that the types compared have a significant effect on collaboration skills. Furthermore, to determine which type of blended learning is more effective in improving collaboration skills, we can refer to the estimated marginal means. The further test results for the collaboration skills variable are presented in Table 9.

Table 9 shows the average difference between the different types of blended learning applied in this study on students' collaboration skills. The station rotation type obtained the highest score (83.96), indicating that the station rotation type is significantly more effective in improving collaboration skills. While the pedati type (81.72) and lab rotation (81.51) fall into the same group, meaning that these two

types are not significantly different from each other in improving collaboration skills, although both are still superior compared to STAD. The STAD type with an average (77.98) indicates that it is less effective in developing collaboration skills when compared to the other blended learning types. Station rotation has a special activity called collaborative activities and stations that can stimulate collaboration among students (Staker & Horn, 2012). This finding is in line with previous research that implementing station rotation learning is effective in encouraging collaboration among students through group discussions and collaborative projects. This approach enhances peer interaction while optimally developing teamwork skills (Harb, 2019; Yukhymenko et al., 2024). Blended learning of the cart and lab rotation types has similar effects on collaboration skills. This is due to the similarity in the learning structure of both types, particularly in the second rotation. In the cart type, the "explore" phase, and the lab rotation type, the "discussion" phase, both adapt learning through online discussion forums. Both types provide equal opportunities for students to discuss topics posted by teachers in the LMS forum. Research by Damayanti & Nuzuli (2023) supports this finding by showing that online discussion forums positively contribute to increased student interaction and encourage more structured and in-depth collaboration. STAD does not utilize online platforms, so all learning takes place offline. This condition makes the development of collaboration skills less optimal compared to other blended learning types that use technology. Research by Protsiv et al. (2016) states that technology-assisted learning approaches can enhance collaboration.

Table 9.
Corrected Average Value

Type	Mean
Blended Learning Station Rotation Type	83.96[a]
Blended Learning Pedati Type	81.72[b]
Blended Learning Lab Rotation Type	81.51[b]
Student Team Achievement Division (STAD)	77.98[c]

Station rotation type shows an influence on collaboration skills because it allows students to interact and work together in groups in a structured manner. One of the main aspects of station rotation is student collaboration (Yukhymenko et al., 2024). This finding is in line with the ideas of Fulbeck et al. (2020), who emphasized that one of the criteria for this type is that the class must be divided into groups. In the station rotation type, there is 1 station called "collaborative activities and stations" where students will participate collaboratively and work together in completing tasks in a group. In accordance with the view of Fazal & Bryant (2019), the application of station rotation in blended learning includes teaching in small groups in the form of collaborative learning. Station rotation type changes the way students learn to collaborate more with peers. Station rotation blended learning allows teachers to work with smaller groups of students (Akinoso et al., 2020). With this type, students can complete their learning activities at the same time and speed, according to the teacher's direction and schedule (Kömür et al., 2023). According to Harb (2019) station rotation is a lesson for successful collaborative development. It has the potential to help teachers implement a student-centered approach with a wide range of adjustments, supervision, and flexible peer collaboration, even with large class sizes.

The type of lab rotation in its application applies focused group discussions (Alim et al., 2023). Lab rotation fosters a culture of intellectual curiosity, openness to new ideas, and the ability to collaborate across boundaries (Bryson et al., 2024). This approach encourages collaborative discussion (Pitso-Mbili et al., 2023) literature supports the idea that lab rotation blended learning has significant potential by combining online resources and collaborative learning activities, thus creating an engaging and interactive learning environment that meets a variety of student needs and preferences (Almarzuqi et al., 2024). Students who apply this type tend to contribute higher-perceptive ideas during class discussions (Cruz, 2019). Blended learning type of lab rotation allows each student to work on skills that suit their needs (Kazakoff et al., 2018). The use of the lab rotation model makes students more focused on learning activities because there are teachers who monitor each activity. The class becomes more conducive because activities are carried out together, which causes the learning process to run more optimally (Ambarli et al., 2020). This model is suitable for use in learning because it has great potential to train good skills in students (Dewi et al., 2023).

The Pedati type assembles a learning flow, one of which is asynchronous. This learning flow allows interaction between students, including collaborative asynchrony in the form of discussion forums and

online assignments that are assembled in such a way as to become an interactive, interesting learning object, and produce the best possible learning experience. Collaborative asynchrony is learning that occurs in a collaborative situation (involving more than one person), between learners and other learners facilitated by discussion forums, mailing lists, assignments, and others (Chaeruman, 2018). In the third stage of Pedati activities, namely "Application," student activity increased through collaboration skills or group work in completing tasks (Handayani, 2022). Meanwhile, according to Jultri, (2020), in the second stage, namely "Deepening," students can understand the material both independently and collaboratively. If exploring the material is done collaboratively, then students and their peers can use online discussion media.

Based on the description above, it can be stated that the application of various types of blended learning influences student collaboration. According to Okaz, (2015), blending technology with face-to-face instruction can stimulate learning and provide a more collaborative learning experience. This opinion is in line with (Protsiv et al., 2016), who state that technology-assisted teaching approaches, such as blended learning, can stimulate collaboration. It offers a combination of various patterns of social interaction (Medina, 2018). Computer technology and the internet have a huge influence on the effectiveness of education. Students can quickly solve problems, make decisions, interact with each other and work together (Adnan, 2015). Biology learning strives to form students who can contribute to developing science and technology (Adnan et al., 2021). Therefore, integrating technology into teaching methods is an effective way to inspire the current generation to attend classes and stay engaged. Using online collaboration platforms can create a dynamic learning environment connected with tech-savvy students (Sekhar & Goud, 2024). Learning through collaboration is important in the learning process as it involves multiple groups and teams of learners working together to solve multiple problems. Thus, collaboration becomes a vital and important skill for students to thrive in the 21st century (Riaz & Din, 2023). Blended learning continues to grow in popularity with the aim of simplifying and enhancing learning, supporting collaboration, creativity, and equipping the skills needed to live in an increasingly digital world (McGuinness & Fulton, 2019). The limitations of this study lie in the devices used by the students, particularly mobile phones with varying specifications, which led to differences in their experiences accessing the LMS.

CONCLUSION

Blended learning of station rotation, lab rotation, and pedati types affect students' collaboration skills. Among the three types, station rotation blended learning proved to be the most effective in influencing collaboration skills, followed by pedati type, then lab rotation type. This shows that learning that involves moving between stations, with one special station, namely collaborative activities and stations, can provide more opportunities for students to interact, discuss, and work together with their group mates to complete the task. Thus, the implementation of station rotation blended learning can be a recommended learning type to improve students' collaboration skills during learning.

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REFERENCES

Adiwisastra, M. F., Mulyani, Y. S., Alawiyah, T., Wibisono, T., Iskandar, I. D., & Purnia, D. S. (2020). Implementation of the Lab Rotation Model in Blended Learning Based on Student Perspectives. *Journal of Physics: Conference Series*, *1641*(1). https://doi.org/10.1088/1742-6596/1641/1/012038

Adnan, Mulbar, U., & Bahri, A. (2021). Scientific Literacy Skills of Students: Problem of Biology Teaching in Junior High School in South Sulawesi, Indonesia. In *International Journal of Instruction* (Vol. 14, Issue 3, pp. 847–860). Gate Association for Teaching and Education. https://doi.org/10.29333/iji.2021.14349a

Adnan. (2015). Model Pembelajaran Biologi Konstruktivistik Berbasis Tik (Mpbk Berbasis Tik) untuk Siswa SMP. In *Journal of EST* (Vol. 1, Issue 1). https://ojs.unm.ac.id/JEST/article/view/1132

Adnan., Saenab, S., & Saleh, A. R. (2016). Unleash Students' Motivation with Blended Knowledge Transfer Instructional Model. *In ICMSTEA 2016: International Conference on Mathematics, Science, Technology, Education, and their Applications* (pp. 240-243).

https://ojs.unm.ac.id/icmstea/article/view/2659
Akinoso, S. O., Agoro, A. A., & Alabi, O. M. (2020). Effect of Station Rotation Mode of Instructional Delivery for Mathematics in the Era of Advancing Technology. *Journal of the International Society for Teacher Education, 24*(2), 60-72. https://files.eric.ed.gov/fulltext/EJ1304479.pdf
Alim, S., Petsangsri, S., & Morris, J. 2023. Lab Rotation Blended Learning Model in Promoting Computational and Critical Thinking: An Assessment of Multiple Stakeholder Needs. *Official Conference Proceedings. The Asian Conference on Education.* https://doi.org/10.22492/issn.2186-5892.2024.128
Alkursheh, T. O. (2024). Factorial Validation of the University Students' Attitudes Toward Blended Learning Scale: An Exploratory and Confirmatory Analysis. *Journal of Pedagogical Research*, *8*(1), 44–60. https://doi.org/10.33902/JPR.202423851
Almarzuqi, A. A., Sulaiman, T. Bin, & Mustakim, S. S. (2024). Effects of Blended Learning Through Lab-Rotation (BLLR) Model on Motivating High School Students to Learn Chemistry Subject. *International Journal of Academic Research in Business and Social Sciences*, *14*(6)493-503.. https://doi.org/10.6007/ijarbss/v14-i6/21682
Almuhaimeed, A. (2022). Evaluating The Validity of Saudi English Language Undergraduate Students' Results in Light of Proposed Criteria. *Journal of Language and Linguistic Studies* (Vol. 18). https://www.jlls.org/index.php/jlls/article/view/3818
Ambarli, S., Syahrial, Z., & Sukardjo, M. (2020). Pengaruh Model Blended Learning Rotasi dan Kecerdasan Intrapersonal Terhadap Hasil Belajar IPA di SMP. *Visipena, 11*(1), 16-32. http://dx.doi.org/10.46244/visipena.v11i1.1089
Andika, A.N.A., Adnan, & Jamaluddin, A.B. Improving the Digital Literacy Skills of Junior High School Students through Blended Learning. *Jurnal Pendidikan MIPA*, *26*(1), 412–428. https://doi.org/10.23960/jpmipa/v26i1.pp412-428
Barkley, B., Lee, D., & Eadens, D. (2014). Perceptions of School Climate and Culture. *EJEP: Ejournal of Education Policy.* ISSN: 2158-9232. https://in.nau.edu/wp-content/uploads/sites/135/2018/08/BarkleyLeeEadens-ek.pdf
Bersamin, A. E., Ulla, M. B., Saripa, A., & Suebsom, K. (2024). Exploring Social Presence through Group Collaboration in Blended Learning. *TESL-EJ*, *28*(1), 1-16. https://doi.org/10.55593/ej.28109int
Bouilheres, F., Le, L. T. V. H., McDonald, S., Nkhoma, C., & Jandug-Montera, L. (2020). Defining Student Learning Experience through Blended Learning. *Education and Information Technologies*, *25*(4), 3049–3069. https://doi.org/10.1007/s10639-020-10100-y
Bradley, V. M. (2020). Learning Management System (LMS) Use with Online Instruction. *International Journal of Technology in Education*, *4*(1), 68–92. https://doi.org/10.46328/ijte.36
Brown, S., Murphy, L., & Hammond, K. (2021). Learning Management System Adoption by Academics: A Perspective Following the Forced Lockdown of NZ Universities due to COVID-19 in 2020. *Journal of Open, Flexible and Distance Learning, 25*(2), 55-65. https://jofdl.nz/index.php/JOFDL/article/view/477
Bryson, T., Grunert Kowalske, M., Wilkins-Yel, K., & Adineh, S. (2024). Examining Black and Latinx STEM graduate students' laboratory rotation experiences and their impact on advisor selection. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1299315
Campbell, D. T., Stanley, J. C., Mifflin, H., Boston, C., Geneva, D., Hopewell, I., Palo, N. J., & London, A. (1963). *Experimental and Quasi-Experiment Al Designs For Research*. USA: Houghton Mifflin Company.
Cantaş, Ç., Soyer, C., & Batur, Ö. (2024). Examination of Undergraduate Students' Artificial Intelligence Anxiety, Multidimensional 21st Century Skills, And Lifelong Learning Levels in Terms of Various Variables. *TOJET: The Turkish Online Journal of Educational Technology, 23*(3), 29–53. https://psycnet.apa.org/record/2025-11103-003
Chaeruman, U. A. (2018). *PEDATI Model Desain Sistem Pembelajaran Blended*. Direktorat Pembelajaran Kementrian Riset, Teknologi dan Pendidikan Tinggi.
Cruz, L.R.B. 2019. Modified Lab Rotation Model: A Blended E- Learning Approach to Improve Student's Conceptual Understanding of English Verb Tense and Aspect. *Official Conference Proceedings*. The Asian Conference on Education. https://papers.iafor.org/submission52608/
Dakhi, O., Jama, J., & Irfan, D. (2020). Blended Learning: A 21st Century Learning Model at College. *International Journal of Multi Science, 1*(08), 50-65. https://multisciencejournal.com/index.php/ijm/article/view/92
Damayanti, D., & Nuzuli, AK (2023). Evaluasi Efektivitas Penggunaan Teknologi Komunikasi dalam Pengajaran Metode Pendidikan Tradisional di Sekolah Dasar. *Jurnal Penelitian dan Pengembangan Scientech*, *5* (1), 208-219. https://doi.org/10.56670/jsrd.v5i1.130
Danso, S. A. (2018). Moral Education and the Curriculum: The Ghanaian Experience. *International Journal of Scientific Research and Management (IJSRM)*, *6*(01), 34-42. https://doi.org/10.18535/ijsrm/v6i1.el05
Dewi, N. R., Listiaji, P., Akhlis, I., Kurniawan, I. O., Siswanto, & Widyaningrum, R. A. (2023). Project-based

Laboratory Rotation Blended Learning Model to Train Students' Critical Thinking and Collaboration in Physics Course. *E3S Web of Conferences*, *400*. https://doi.org/10.1051/e3sconf/202340001023
Diepreye, F. F., & Odukoya, J. A. (2019). (2019). The Impact of Passive and Active Teaching Methods on Students' Learning among Secondary School Students in Yenagoa, Bayelsa State. *Journal of Physics: Conference Series*, *1378*(2). https://doi.org/10.1088/1742-6596/1378/2/022099
Duygu, Ç. (2023). Development of 21st Century Skills During Preschool Period: A Phenomenological Study in Turkiye. *International Journal of Educational Administration and Policy Studies*, *15*(1), 46–63. https://doi.org/10.5897/ijeaps2023.0755
Ellis, R. A., Pardo, A., & Han, F. (2016). Quality in Blended Learning Environments – Significant Differences in How Students Approach Learning Collaborations. *Computers and Education*, *102*, 90–102. https://doi.org/10.1016/j.compedu.2016.07.006
Eryilmaz, S. (2021). Compare Teachers and Students Attitudes According to Mobile Educational Applications. In *TOJET: The Turkish Online Journal of Educational Technology*, *20*(1), 19-24. http://www.tojet.net/articles/v20i1/2013.pdf
Fazal, M., & Bryant, M. (2019). Blended Learning in Middle School Math: The Question of Effectiveness. *Journal of Online Learning Research, 5*(1), 49-64. https://files.eric.ed.gov/fulltext/EJ1208816.pdf
Firman., Nur, S., & Taim, M. A. S. (2023). Analysis of Student Collaboration Skills in Biology Learning. *Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi*, 82–89. https://doi.org/10.33369/diklabio.7.1.82-89
Fulbeck, E., Atchison, D., Giffin, J., Seidel, D., & Eccleston, M. (2020). *Personalizing Student Learning with Station Rotation: A Descriptive Study*. American Institutes for Research.
Ghavifekr, S. (2020). Collaborative Learning: A Key to Enhance Students'social Interaction Skills. *MOJES: Malaysian Online Journal of Educational Sciences*, 8(4), 9-21. https://mojes.um.edu.my/article/view/26394/12190
Gökyer, N., & Cirit, D.K. (2018). Self-Efficacy Levels of Classroom Teachers. *Adıyaman Üniversitesi Eğitim Bilimleri Dergisi*, *8*(2), 135–151. https://doi.org/10.17984/adyuebd.429830
Hamdani, M. S., & Wardani, K. W. (2019). Penerapan Model Pembelajaran Team Games Tournamen (TGT) Pada Pembelajaran Tematik Terpadu Kelas 5 untuk Peningkatan Keterampilan Kolaborasi. *Jurnal Ilmiah Sekolah Dasar*, *3*(4), 431-437. https://doi.org/10.23887/jisd.v3i4.21778
Handayani, B.R. 2022. Peningkatan Hasil Belajar Memahami Prinsip-Prinsip Dasar Animasi 2d Melalui Model Desain Alur Pedati Dengan Blended Learning Bagi Siswa Kelas Xi Mm 3 Smk Negeri 6 Sukoharjo Pada Semester 1 Tahun Pelajaran 2021/2022. *Kastara Karya: Jurnal Pendidikan dan Kebudayaan, 2*(4), 103-112. https://widyasari-press.com/wp-content/uploads/2023/02/11.-Betty-Resmi-Handayani-Peningkatan-Hasil-Belajar-Model-Desain-Alur-Pedati-Dengan-Blended-Learning-.pdf
Harb, G. K. (2019). Reshaping Undergraduates' Research Experience with Station Rotation Learning Model. *International Journal of Advanced Research*, *7*(11), 702–710. https://doi.org/10.21474/IJAR01/10061
Hartina, A.W., Wahyudi., & Permana, I. (2022). Dampak Problem Based Learning untuk Meningkatkan Keterampilan Kolaborasi dalam Pembelajaran Tematik. *Journal of Education Action Research*, *6*(3). https://doi.org/10.23887/jear.v6i3
Hidayati, N., Zubaidah, S., & Amnah, S. (2023a). Effective Learning Model Bases Problem Based Learning and Digital Mind Maps to Improve Student's Collaboration Skills. *International Journal of Evaluation and Research in Education*, *12*(3), 1307–1314. https://doi.org/10.11591/ijere.v12i3.22654
Jamaluddin, A. B., Bahri, A., Pratiwi, A. C., & Lembang, A. M. (2025). ChatGPT as a Pedagogical Tool: Measuring Its Influence on Cognitive Engagement and Academic Achievement of Biology Students. *Jurnal Pendidikan MIPA*, *26*(1), 36-50. https://doi.org/10.23960/jpmipa/v26i1.pp36-50
Jultri, S. (2020). Desain Pembelajaran Pedati Sebagai Alternatif Pengembangan Metode Asinkron. In *Prosiding Seminar Nasional Pembelajaran Bahasa dan Sastra Indonesia* (SemNas PBSI)-3 (pp. 61-66). FBS Unimed Press. https://digilib.unimed.ac.id/id/eprint/41222/1/Fulltext.pdf
Kazakoff, E. R., Macaruso, P., & Hook, P. (2018). Efficacy of a Blended Learning Approach to Elementary School Reading Instruction for Students who Are English Learners. *Educational Technology Research and Development*, *66*(2), 429–449. https://doi.org/10.1007/s11423-017-9565-7
Khoiriyah, S., Wiliyanti, V., & Gunawan, I. (2024). The Influence of The STEM Learning Approach on Students Communication and Collaboration Abilities on Elasticity Materials. *Jurnal Penelitian Pembelajaran Fisika*, *15*(3), 263–271. https://doi.org/10.26877/jp2f.v15i3.18724
Kömür, İ. A., Kilinç, H., & Okur, M. R. (2023). The Rotation Model in Blended Learning. *Asian Journal of Distance Education*, 18(2), 63-74. https://doi.org/10.5281/zenodo.8197798
Köprülü, F., Tangir, R. N., & Öznacar, B. (2022). Lecturers' and Students' Viewpoints of Distance Education During the COVID-19 Pandemic. *Pegem Egitim ve Ogretim Dergisi*, *13*(1), 68–74.

https://doi.org/10.47750/pegegog.13.01.08
Le, H., Janssen, J., & Wubbels, T. (2018). Collaborative Learning Practices: Teacher and Student Perceived Obstacles to Effective Student Collaboration. *Cambridge Journal of Education*, *48*(1), 103–122. https://doi.org/10.1080/0305764X.2016.1259389
Loughlin, C., & Lindberg-Sand, Å. (2023). The Use of Lectures: Effective Pedagogy or Seeds Scattered on The Wind? *Higher Education*, *85*(2), 283–299. https://doi.org/10.1007/s10734-022-00833-9
McGuinness, C., & Fulton, C. (2019). Digital Literacy in Higher Education: A Case Study of Student Engagement with E-Tutorials Using Blended Learning. *Journal of Information Technology Education: Innovations in Practice*, *18*, 1–28. https://doi.org/10.28945/4190
Medina, L. C. (2018). Blended Learning: Deficits and Prospects In Higher Education. *Australasian Journal of Educational Technology, 34*(1). 42-56. https://doi.org/10.14742/ajet.3100
Mphahlele, R. S., Sethusha, M. J., Makgato-Khunou, P., Tshesane, M. S. M., Wright, R., Chetty, D., & Tshephe, G. P. (2023). First-Year Student's E-Readiness to Use Learning Management System: COVID-19 Realities. *International Journal of E-Learning & Distance Education*, *38*(1). https://doi.org/10.55667/ijede.2023.v38.i1.1266
Mu'arifah, H., Citraning, R., & Mukaromah, S. (2023). Peningkatan Keterampilan Kolaborasi Siswa dengan Metode TTS (Tutor Teman Sebaya) pada Mata Pelajaran Biologi. *Jurnal Pendidikan Guru Profesional, 1*(1), 69-72. https://doi.org/10.26877/jpgp.v1i1.171
Nahar, S., Suhendri, Zailani, & Hardivizon. (2022). Improving Students' Collaboration Thinking Skill under the Implementation of the Quantum Teaching Model. *International Journal of Instruction*, *15*(3), 451–464. https://doi.org/10.29333/iji.2022.15325a
Nurmayasari, K. V., Pantiwati, Y., Wahyuni, S., Susetyarini, R. E., & Hindun, I. (2022). Studi Kemampuan Kolaborasi Siswa dalam Pembuatan Herbarium Materi Klasifikasi Makhluk Hidup. *Jurnal Education and Development*, 10(2), 246-251. https://doi.org/10.37081/ed.v10i2.3667
Okaz, A. A. (2015). Integrating Blended Learning in Higher Education. *Procedia - Social and Behavioral Sciences*, *186*, 600–603. https://doi.org/10.1016/j.sbspro.2015.04.086
Oladele, O. M., Funmi, K. B., & Ruth, O. A. (2019). The Impact of World Bank and Other International Organizations on Higher Education System in Nigeria. *International Journal of Education and Literacy Studies, 7*(3), 76-82. https://doi.org/10.7575/aiac.ijels.v.7n.3p.76
Pitso-Mbili, A. R. M., Mzileni, Y. N., & Mtayisi, N. R. (2023). Exploring the Lab Rotation Model in Hospitality Management Education. *In University of Fort Hare Teaching and Learning Conference* (UFHTL 2023) (pp. 79-104). Atlantis Press. https://doi.org/10.2991/978-94-6463-439-6_
Protsiv, M., Rosales-Klintz, S., Bwanga, F., Zwarenstein, M., & Atkins, S. (2016). Blended learning Across Universities in a South-North-South collaboration: A Case Study. *Health Research Policy and Systems*, *14*(1). https://doi.org/10.1186/s12961-016-0136-x
Riaz, M & Din, M. (2023). Collaboration as 21st Century Learning Skill at Undergraduate Level. *Sjesr*, *6*(1), 93–99. https://doi.org/10.36902/sjesr-vol6-iss1-2023(93-99)
Sailer, M., Stadler, M., Schultz-Pernice, F., Franke, U., Schöffmann, C., Paniotova, V., Husagic, L., & Fischer, F. (2021). Technology-related teaching skills and attitudes: Validation of a scenario-based self-assessment instrument for teachers. *Computers in Human Behavior*, *115*. https://doi.org/10.1016/j.chb.2020.106625
Salcedo, M. D. C. N. (2022). Perception of Blended Learning in Faculty and Students of Higher Learning. *International Journal of Education and Practice*, *10*(3), 227–236. https://doi.org/10.18488/61.v10i3.3069
Sekhar, P. R., & Goud, S. (2024). Collaborative Learning Techniques in Python Programming: A Case Study with CSE Students at Anurag University. *Journal of Engineering Education Transformations*, *38*, 243–249. https://journaleet.in/index.php/jeet/article/view/2282
Sihawong, U., & Phusee-orn, S. (2023). Developing a Model to Enhance Junior High School Teacher 21st Century Learning Management Competencies. *Journal of Education and Learning*, *13*(1), 101. https://doi.org/10.5539/jel.v13n1p101
Söylemez, N. H. (2023). Teacher and Student in the 21st Century: A Mixed Design Research. *International Journal of Psychology and Educational Studies*, *10*(3), 758–772. https://doi.org/10.52380/ijpes.2023.10.3.1128
Staker, H., & Horn, M.B. 2012. *Classifiying K-12 Blended Learning*. Afrika Selatan: Innosight Institute.
Su, C. S., Seckel, M. J., & Vásquez, C. (2022). What Learning Opportunities Does the Chilean Primary Education Curriculum Offer to Train in Sustainability?. *Mathematics Teaching Research Journal, 14*(3), 108-132, https://files.eric.ed.gov/fulltext/EJ1361577.pdf
Sun, L., Asmawi, A., Dong, H., & Zhang, X. (2024). Exploring The Transformative Power of Blended Learning for Business English Majors in China (2012–2022) – A bibliometric voyage. In *Heliyon* (Vol. 10, Issue 2). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2024.e24276
Tikkanen, L., Anttila, H., Ulmanen, S., & Pyhältö, K. (2024). Peer Relationships and Study Wellbeing: Upper Secondary Students' Experiences. *Social Psychology of Education*, *27*(6), 3097–3117.

https://doi.org/10.1007/s11218-024-09942-y
Turnbull, D., Chugh, R., & Luck, J. (2023). Learning Management Systems and Social Media: A Case for Their Integration in Higher Education Institutions. *Research In Learning Technology*, *31*. https://doi.org/10.25304/rlt.v31.2814
Tutar, H., & Serpil, H. (2024). Up-Close And Social Risks in Distance Higher Education: A Qualitative Analysis of Emergency Remote Teaching Experiences. *Turkish Online Journal of Distance Education*, *25*(4), 230-243. https://doi.org/10.17718/tojde.1309938
Vieyra, Mtro. G. Q., & González, L. F. M. (2023). Platforms for Online Learning: A Product Specification. *European Journal of Education*, *6*(2), 33–42. https://doi.org/10.2478/ejed-2023-0014
Yukhymenko, V., Borysova, S., Bazyl, O., Hubal, H., & Barkar, U. (2024). Modelo De Rotação De Estações De Aprendizagem Em Banda No Ensino Superior. *Conhecimento & Diversidade, 16*(41), 182-202. https://doi.org/10.18316/rcd.v16i41.11434
Yüksel, F. Ş., Kayadelen, A. N., & Antmen, F. (2023). A Systematic Literature Review on Multi-Criteria Decision Making in Higher Education. *International Journal of Assessment Tools in Education*, *10*(1), 12-28. https://doi.org/10.21449/ijate.1104005