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The development of MOOCs on students' learning outcomes in science subjects

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ABSTRACT

Educational institutions may apply digital platforms to enhance the quality of learning, hence improving student outcomes through E-Learning, including Massive Open Online Courses (MOOCs). This study aims to develop Massive Open Online Courses (MOOCs) on student learning outcomes in natural science disciplines, facilitating a deeper comprehension of the content and equipping them for future academic and professional endeavors. This study employs the ADDIE development, comprising five stages: analysis, design, development, implementation, and evaluation. Analysis results state that students prefer collaborative, visual, and interactive learning approaches over traditional methods such as reading. Desain results show that designing learning material through web-based MOOCs is needed. Implementation stated that this platform helps them achieve their learning goals and provides a pleasant experience. Evaluation results show that intervention or treatment has a positive impact on improving performance. The paired sample t-test indicates a significant difference in student learning outcomes between the pretest and post-test. It can be concluded that implementing MOOCs significantly enhances students' learning outcomes, particularly in natural science.

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ABSTRAK

Lembaga pendidikan dapat menerapkan platform digital untuk meningkatkan kualitas pembelajaran, sehingga meningkatkan hasil siswa melalui E-Learning, termasuk Massive Open Online Courses (MOOCs). Penelitian ini bertujuan untuk mengembangkan MOOCs untuk meningkatkan hasil belajar siswa dalam mata pelajaran Ilmu Pengetahuan Alam, membantu mereka memahami materi secara lebih mendalam, dan mempersiapkan mereka untuk pendidikan dan karier di masa depan. Penelitian ini menggunakan model pengembangan ADDIE, yang terdiri dari lima tahap: analisis, desain, pengembangan, implementasi, dan evaluasi. Hasil analisis menunjukkan bahwa siswa lebih menyukai pendekatan pembelajaran kolaboratif, visual, dan interaktif dibandingkan metode tradisional seperti membaca. Hasil desain menunjukkan bahwa merancang materi pembelajaran melalui MOOCs berbasis web sangat diperlukan. Hasil implementasi menunjukkan bahwa siswa merasa platform ini membantu mereka mencapai tujuan pembelajaran dan memberikan pengalaman belajar yang menyenangkan. Hasil evaluasi menunjukkan bahwa intervensi atau perlakuan ini memberikan dampak positif dalam meningkatkan kinerja siswa. Uji-t sampel berpasangan menunjukkan perbedaan yang signifikan dalam hasil belajar siswa antara pretest dan post-test. Dapat disimpulkan bahwa penerapan kursus MOOCs secara signifikan meningkatkan hasil belajar siswa, khususnya di bidang ilmu alam.

Kata Kunci: *hasil belajar siswa; IPA; keefektifan; MOOCs*

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INTRODUCTION

The development of science and technology has had many impacts on various fields, including education (Shlianchak et al., 2024). Technology can make monotonous learning activities enjoyable, such as using technology as a tool to deliver material (Asarta & Schmidt, 2020). Information technology is invaluable in strengthening communication between all parties involved in education (Szymkowiak et al., 2021). Education faces many significant challenges this century (Atoy et al., 2020). If teaching methods are not updated, we risk facing great difficulties in dealing with the continuously developing needs and demands of learning in today's modern era (Nuraini et al., 2022). In education, teachers have an essential role in utilizing technology, the impact of which will automatically be felt by students (Firdaus et al., 2024). Several skills are required for teacher competence, including compiling learning materials. Teachers' skills in compiling learning materials will be significantly assisted by technology (Schmid et al., 2021), which is increasingly sophisticated (Nurhikmah et al., 2024). The rapid advancement of technology brings many benefits to life. There seem to be many threats resulting from technology (Nurhikmah et al., 2021). According to (Azhari et al., 2022), the progress of information technology cannot be fully supervised by the government, which negatively impacts society (Sasabone et al., 2022).

There needs to be a proper adjustment between the progress of Science and Technology with adequate supervision and regulation to reduce negative impacts and optimize its benefits for the welfare of society. In facing this challenge, the government has made regulations to prohibit anyone from intentionally and without the right to distribute and/or transmit and/or make accessible electronic information and/or electronic documents that contain insults and/or defamation. Technology is generally defined as anything that makes our lives easier. The influence of technology on education is very significant (Imran et al., 2022). The two are increasingly closely connected because their respective roles support each other. In the era of globalization, all learning materials can be accessed quickly, which is very helpful for teachers and students in carrying out teaching and learning activities (Djazilan & Hariani, 2022). The observation results showed that the problem faced by teachers and students of SMP Negeri 19 Makassar, especially in learning science (Natural Sciences), is the lack of learning resources other than printed books, so the teacher provides another alternative, namely asking students to print each material or LKPD being studied.

In addition, students can independently access the internet to find other learning resources such as journals, articles, and learning videos on the YouTube platform. The characteristics of middle school students who have high independence, the ability to use technology, and prefer visual and interactive forms are considerations for implementing enjoyable learning for students, such as the use of Massive Open Online Courses (MOOCs) in learning that can accommodate teaching materials such as reading, pictures, animations, videos, and learning games. MOOCs provide flexible access so students can organize the time, place, and learning method according to their conditions. Students can learn according to their abilities and speed in understanding science subject matter. Additional sources, such as interactive quizzes and discussion forums, can improve their understanding of the learning topics the teacher gives. In this study, learning materials such as readings, animations, images, videos, and quizzes are arranged and edited using several applications that will be integrated into MOOCs so that students can flexibly and independently access learning materials on their respective gadgets.

Some previous studies found that motivation, perceived learning support, and learning engagement are key factors influencing perceived learning outcomes in MOOCs. These elements contribute significantly to how learners evaluate their success and learning outcomes within these courses (Wei et al., 2023). MOOCs can enhance learning outcomes by motivating and supporting learners, sustaining their focus on essential content, fostering self-directed and collaborative learning skills, improving time management and task persistence, and addressing the needs of non-native English speakers (Jung & Lee, 2020). MOOCs

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offer diverse learning materials in various formats, including videos, PDFs, and slideshows, catering to different proficiency levels, such as beginner, intermediate, and advanced (Ewais & Samara, 2020). Based on previous studies discussing the development of MOOCs, this study offers some news that can contribute to the world of education. Many studies on MOOCs have been conducted; Motivation, perceived learning support, and engagement are critical factors influencing perceived learning outcomes in MOOCs. These courses can enhance outcomes by motivating learners, providing support, fostering essential skills like self-directed learning and time management, and addressing the needs of non-native English speakers. Additionally, MOOCs offer diverse learning materials in various formats and levels, accommodating many learners (Danka, 2020; Giasiranis & Sofos, 2020).

The study aims to develop MOOCs on student learning outcomes in natural science disciplines. The novelty of this study provides important insights into how MOOCs can revolutionize science education by tackling the distinctive challenges and opportunities associated with teaching natural sciences. By emphasizing varied measures of learning outcomes, integrating innovative teaching methods, utilizing advanced technological tools, and examining the role of MOOCs, the research underscores their potential to expand access to high-quality science education, enhance practical skills, and deliver lasting educational and career advantages to learners from diverse backgrounds and cultural settings. Concerning the aforementioned problem formulation, this study aims to test the effectiveness of MOOCs on student learning outcomes in natural science disciplines, facilitating a deeper comprehension of the content and equipping them for future academic and professional endeavors at SMP Negeri 19 Makassar. This research may contribute to the literature on the efficacy of technology in enhancing student learning outcomes and facilitating the formulation of creative learning strategies pertinent to the digital era.

LITERATURE REVIEW

Massive Open Online Courses (MOOCs)

The learning implementation plan for primary and secondary education needs to be prepared with an integrated, systematic, and efficient application of information and communication technology (ICT), and it needs to be matched to the conditions already in place. Therefore, utilizing learning material integrated with information and communication technology is necessary to maximize the effectiveness of the educational process inside the classroom (Oksatianti et al., 2022). Nowadays, digital technology has become an essential tool in the learning process in educational institutions (Imran et al., 2022). Digital technology as a learning medium plays a significant role in supporting and enriching the learning experience and improving students' abilities and skills (Wei et al., 2023). Along with developing ICT based on ICT, learning is now designed web-based, allowing students to learn interactively through E-learning (Otynshina et al., 2024). The quality of teachers is required to be increasingly high, along with the development of ICT to create learning methods that continue to progress (Ewais & Samara, 2020).

Educational units can utilize digital platforms to improve the quality of their learning so that student learning outcomes can improve through E-Learning, such as Massive Open Online Courses (MOOCs). MOOCs are a learning platform with the principle of openness. They utilize technology to become a trend for future education, making it easier for people to obtain education. MOOCs can be a source of student learning that aligns with the development of today's technology because they can summarize several media at once, and students can access MOOCs wherever and whenever they are in class and outside the classroom (Jung & Lee, 2020). One of the main characteristics of MOOCs is their openness. Unlike traditional education, which often requires formal enrollment and high tuition fees, MOOCs are usually free and can be accessed by anyone. Some well-known MOOC platforms such as Coursera, edX, and Udemy offer thousands of courses from leading institutions such as Harvard, MIT, and Stanford. These courses

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cover various topics ranging from computer science and business to art and design, allowing participants to gain new knowledge and skills without being limited by location or finances.

In Indonesia, MOOCs have become part of a broader educational initiative, particularly in supporting the Kampus Merdeka program initiated by the Ministry of Education and Culture. The Kampus Merdeka program aims to provide students with the freedom to choose courses and learning activities outside of campus, where MOOCs are one of the media used to achieve this goal. Students can take online classes from local and international institutions, which are recognized as part of their academic credits. This broadens access to quality education and prepares students to face global challenges by equipping them with relevant skills and knowledge. In addition, MOOCs are often criticized for the lack of direct interaction between instructors and participants, which can affect the quality of learning. However, with the advancement of technology and the adaptation of better teaching methods, MOOCs have great potential to continue to grow and play an essential role in education in the future (Aryana et al., 2022). With the rapid advancement in digital technology, especially in education, many platforms offer courses or open learning materials that can be accessed widely via the Internet (Imran et al., 2022; Sasabone et al., 2022). These platforms, known as MOOCs, provide various skill and learning packages that anyone who needs them can take (Putra et al., 2023).

Natural Science

Natural Science subjects at the junior high school level help develop students' understanding of basic science concepts and train critical and analytical thinking skills. Science plays an important role in solving various problems in people's daily lives. However, its application must be done wisely so as not to damage the surrounding environment and still pay attention to human needs. Natural science subjects are inseparable from human life when interacting with the surrounding environment. Natural Science subjects is a science that studies nature, starting from living things and inanimate objects, biology, chemistry, and geology. Natural Science encourages students to be able to think critically, logically, and creatively in solving a problem through observation or experimentation, as well as a scientific understanding of phenomena that occur in nature (Sarumaha et al., 2022).

Digital technology is invaluable in science learning because the material is delivered interactively and engagingly through simulations, videos, or visualizations of complex natural phenomena. MOOCs as a source of student learning can also facilitate collaboration and communication between students and teachers, improving students' effectiveness and learning outcomes in Natural Sciences subjects. This study uses the topic of Introduction to Cells, Structure, and Function of Living Things, Effort, Energy and Simple Machines in the subject of Natural Science, the science teacher's guidebook for junior high school grade VIII, which is a reference book for teachers at SMP Negeri 19 Makassar for the 2024/2025 academic year. The materials that will be used as content in MOOCs are as follows. Cells and Microscopes, Animal Cells and Plant Cells, Cell Specialization, Food and Digestive System, Circulatory System, Respiratory System, Excretory System, Work, Energy, and Simple Machines.

Learning Outcomes

Learning outcomes describe the abilities or competencies obtained by students after undergoing a learning process that is apparent through changes in behavior, habits, skills, attitudes, and abilities that are assessed and observed. Learning outcomes refer to the achievements obtained by students after completing a specific subject matter. This is the result of the learning process, which can be interpreted as the mastery of knowledge reflected in changes in student behavior. Each student has different abilities in receiving and applying information. Some understand concepts quickly, moderately, or slowly,

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depending on the way individuals absorb knowledge, which varies. Therefore, the quality of education in Indonesia needs to be improved so that all Indonesian children have the same right to education, considering each student's character (Aswat et al., 2022; Sujarwo et al., 2023). In addition, teachers must be able to adapt to technological developments to create learning media that can identify students' learning needs and interests. Student learning outcomes are often used as the primary indicator to assess the effectiveness of the learning process.

The success of a teaching method is usually measured based on what is achieved and the development of students in the learning process (Febriati et al., 2022). Other research on MOOCs has emerged as a future education trend that offers a flexible learning system, can be accessed by many people on a large scale, and helps develop skills and knowledge (Giasiranis & Sofos, 2020). However, despite the various benefits and opportunities, MOOCs face many challenges, especially regarding time management and processes. Other research discussing MOOCs produced positive findings because this media is suitable for use by students. MOOCs can make it easier for teachers and students to access and use learning materials (Somayana, 2020). Therefore, education must be designed to develop practical skills and knowledge relevant to the needs of the workplace and society. In practice, each student's learning outcomes tend to vary. Each student has different abilities, and many factors influence their level of achievement. Because of these differences, it is impossible to equate learning outcomes between one student and another (Yang et al., 2021).

Therefore, Education can change individuals' perspectives, cultures, and behaviors (Yandi et al., 2023). In addition, education is important in helping humans understand aspects of life and play an active role in every change. The use of MOOCs provides students with the opportunity to interact with learning materials independently and collaboratively. This approach emphasizes the active role of students in creating their understanding. Constructivism theory supports the use of MOOCs as a learning resource. Constructivism is applied in online learning so that students are more active in learning and teachers only act as facilitators (Budyastuti & Fauziati, 2021). The learning materials developed can help students learn independently so that they do not depend on learners as the only source of information. Constructivism theory holds that learning is not a process of passively receiving information from teachers, which means that students only receive knowledge from teachers without being actively involved in the learning process. Still, students actively form their understanding based on their experiences and thoughts.

METHODS

This research can help students follow the learning process inside and outside the classroom. It will culminate in creating a learning web or platform comprising online discussion rooms, interactive tests, videos, animations, and materials. To test the effectiveness of using MOOCs in learning science subjects on student learning outcomes using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) development model developed by Reiser and Molenda. This research utilized the ADDIE approach.

This study will be carried out at SMP Negeri 19 Makassar during the odd semester of the 2024–2025 school year. The researcher chose the research location to get an overview and information about students' learning outcomes when following a learning process that only uses reading books as a learning resource. The research will then be developed into a product of MOOCs to improve students' learning outcomes. There are two validators, consisting of material and media experts. Mrs. Asma S.Pd. is the natural sciences subject teacher. Twenty students from grade VIII were selected as product trial participants at SMP Negeri 19 Makassar.

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Development Steps

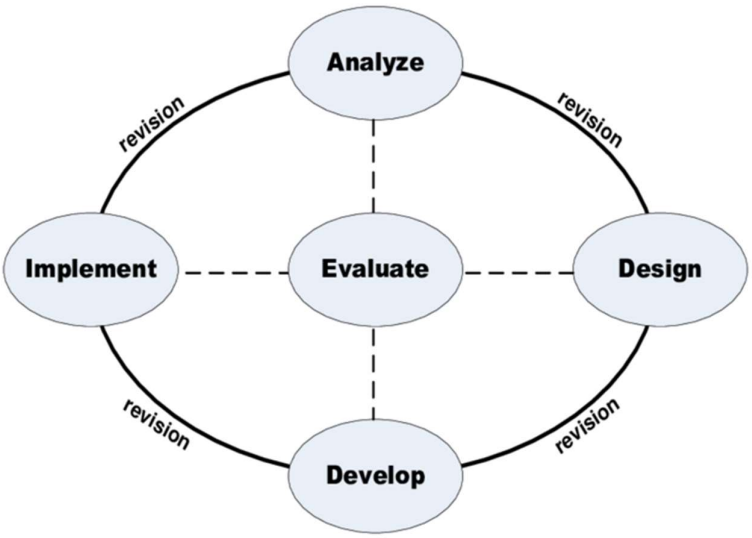

Figure 1. ADDIE Model Stages
Source: Research Design 2024

Figure 1 explains the five steps of the ADDIE model—analysis, design, development, implementation, and evaluation—used in this study's development research. The following steps outline the activities carried out during the research process.

1. Analysis
   A needs analysis was conducted to identify problems in schools related to teaching methods by teachers carried out in the initial oversight. Observation activities were carried out by conducting interviews with one of the teachers at the school, namely the Natural Sciences subject teacher for class VIII, and providing a questionnaire containing several questions.
2. Design
   After conducting a needs analysis, the next step is to design learning media as web-based MOOCs. Designing the content of the material in each session that will be included in the MOOCs page in the Natural Sciences subject for grade VIII.
3. Development
   The previously designed design becomes a benchmark in developing MOOCs and is validated by expert media validators using a validation questionnaire.
4. Implementation
   The Implementation Phase deploys the web-based MOOCs for eighth-grade Natural Sciences at SMP Negeri 19 Makassar, ensuring its practical use. It ensures that teachers and students can use the MOOCs platform. It checks internet access and MOOC-accessible devices (computers, tablets, cell phones). It teaches students how to use MOOCs, providing activity instructions, group discussions, quizzes, and other interactive features. Teachers monitor students' platform development and help with technical concerns. Encourage kids to ask questions and discuss online and offline. Maintain technical and pedagogical support for teachers and students to ensure MOOCs integration success. After the product is declared valid, it will undergo a product trial before being used in an actual learning situation. The product trial stage will be conducted at SMP Negeri 19 Makassar, class VIII, with 20 students and 1 Natural Sciences subject teacher.

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5. Evaluation
   At this stage, the quality of web-based MOOCs products will be assessed. The evaluation stage collects data in the form of teacher and student questionnaire responses to measure the effectiveness of the product based on the results of the teacher and student questionnaire responses. The results of this stage are a revision of the product trial results.

Data Collection Instruments

The instruments used in collecting data in this study are as follows.

1. Interview
   The initial data collection in this study used an interview method involving a grade VIII Natural Science teacher as the research subject. The interview was conducted to explore information related to the teaching methods used by the teacher. The interview with the teacher aimed to gain perspectives on examples of teaching methods used and the challenges faced in the learning process.
2. Questionnaire
   This study used an initial data collection instrument: a questionnaire designed to identify the views and responses of teachers and students at SMP Negeri 19 Makassar regarding the use of technology in their learning process. This instrument functions to obtain an initial picture of the perceptions of teachers and students regarding the level of effectiveness, ease of access, and their involvement in the learning process utilizing technology as a learning resource. This questionnaire consists of several questions designed to measure the level of understanding, interest, and impact that will be felt on their learning outcomes. The questionnaire acts as a tool for collecting data that allows researchers to collect quantitative and qualitative information from diverse respondents, which will then be analyzed to support the results of this study.
3. Product Reviews by Experts
   Product reviewers consist of experts in learning design. The supervisor or the study program secretary determines the product reviewers to assess the feasibility of the developed product.
4. Product Trial
   The trial model consists of individual, small, and large-group trials. In this development model, the author uses large group trials to identify technical errors and difficulties of use so that the product can be evaluated before implementation. The large group trial will be conducted with 20 students at SMP Negeri 19 Makassar, class VIII.

RESULTS AND DISCUSSION

This study aims to test the effectiveness of using MOOCs in learning science subjects on student learning outcomes, providing the students with a better understanding of the material and preparing them for future academic and professional challenges. In this study, the development research uses the ADDIE model, which consists of five steps: analysis, design, development, implementation, and evaluation. The following phases mainly explain the actions that were carried out throughout the research process.

Analysis

A requirements analysis was conducted to identify issues in schools associated with teachers' teaching approaches during the initial monitoring. The three methods utilized to carry out the observation activities

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were conducting interviews with one of the teachers at the school, specifically the Natural Sciences subject teacher for class VIII, and presenting a questionnaire containing many questions.

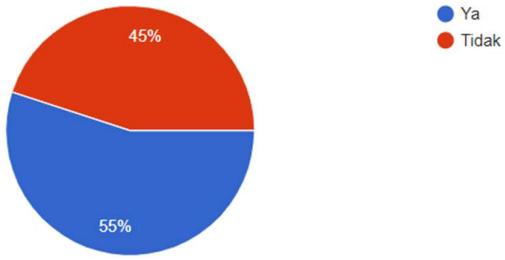

Figure 2. Students' needs
Source: Research, 2024

The survey results in **Figure 2** showed that 55% of 8th-grade students feel bored with the current learning methods, such as learning through printed books only. Meanwhile, 45% of students said they did not feel bored with the method. This data indicates a need to refresh the current learning methods by adding variations, such as technology integration, interactive media, or more creative approaches. This aims to maintain students' interest in learning and increase their involvement.

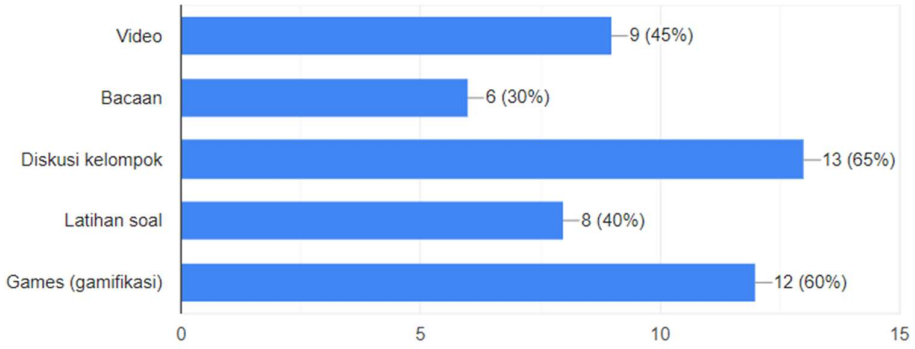

Figure 3. The students need mostly to learn
Source: Research, 2024

Figure 3 shows the survey results on the learning most preferred by 8th-grade students, which showed that group discussions were the most popular method, with 65% of students choosing this option. This method was followed by games (gamification) chosen by 60% of students, indicating that interactive and fun elements were the main attractions in learning. Learning videos were also quite popular, with 45% of students choosing them, while practice questions were preferred by 40% of students. On the other hand, reading was the least chosen method, preferred by only 30% of students. This data confirms that students prefer collaborative, visual, and interactive learning approaches over traditional methods such as reading.

Based on the results of observations conducted at SMP Negeri 19 Makassar, researchers are aware of the importance of MOOCs as a source of student learning in the learning process in the classroom and outside the classroom. It was found that students struggle to understand the subject matter through existing learning methods. Most still use printed books to receive subject matter, but the obstacle is the mismatch between the number of students and the number of books provided by the school, so students are asked to print the books individually. The Natural Sciences subject teacher, a resource person, revealed in the initial observation interview that the current learning media cannot fully increase student involvement in learning activities, impacting low student learning outcomes.

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Design

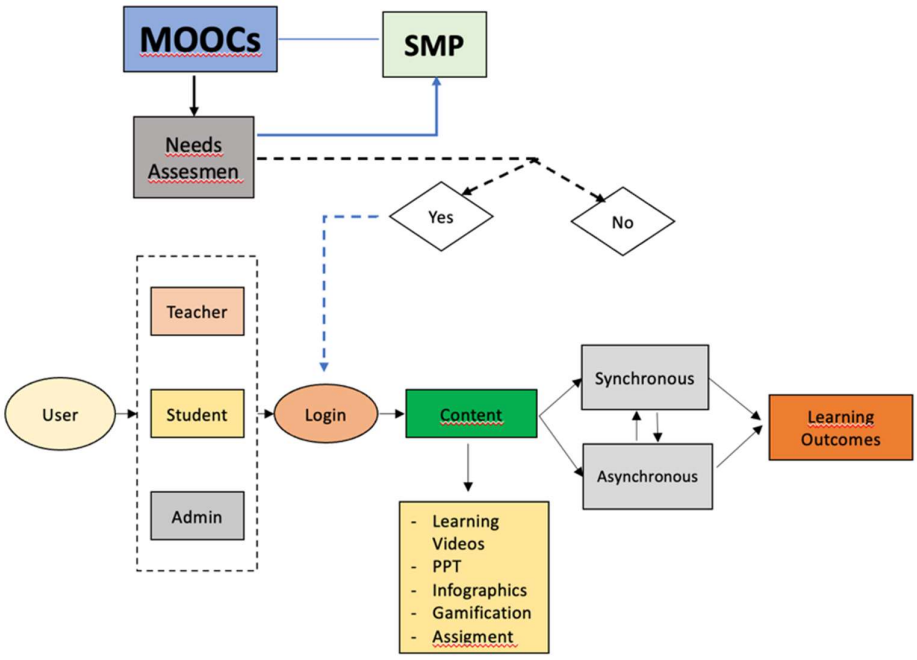

Figure 4. MOOCs Design
Source: Research, 2024

After completing a requirements analysis, the next phase is to design learning material for web-based MOOCs. **Figure 4** shows that developing the content of the information that will be featured on the MOOCs website for the eighth-grade Natural Sciences subject is now underway.

Development

In the process of producing MOOCs, the development designed in the past becomes a benchmark, and it is validated by media validators who are experts in the field using a validation questionnaire. The product will be put through a product trial when it has been determined to be genuine, and then it will be used in a simulated learning environment. Twenty students and one teacher of the Natural Sciences subject will participate in the product trial stage, which will take place at SMP Negeri 19 Makassar, class VIII.

Implementation

In the Implementation Phase, SMP Negeri 19 Makassar delivers web-based MOOCs for eighth-grade Natural Sciences to ensure practical application. It tests the internet and MOOC-accessible devices (computers, tablets, phones). It provides activity instructions, group discussions, quizzes, and other interactive features to teach MOOCs. MOOCs integration success requires technological and pedagogical support for teachers and students. After being validated, the product will be tested before being utilized in authentic learning. The results of the product that was tested on 20 students and one teacher show that most of them were satisfied with the experience and implementation of the MOOCs platform.

The data shows that this platform helps them achieve their learning goals and provides a pleasant experience. Based on the data from 20 students who were respondents, 93% said they felt comfortable accessing subject matter through digital devices, and 86.7% said that they often use digital devices,

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especially smartphones. Although printed books provide many complete learning materials, there are also limitations in the variety of interactive media, such as a lack of stimulation of learning interest, which will later affect student learning outcomes. Proven in learning preferences, as many as 80% of students prefer learning methods involving videos and practice questions that use a gamification approach because they are considered helpful in understanding the subject matter.

Evaluation

The quality of web-based MOOCs products will be evaluated at this level of the evaluation process. The evaluation stage collects data in the form of replies from both teachers and students to determine the product's effectiveness based on the findings of the teacher and student questionnaire responses. At this point, the outcomes of the product study have been revised to reflect the findings of this stage.

Table 1. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	38.75	20	11.107	2.483
	Post-test	81.00	20	6.609	1.478

Source: Research 2024

Table 1 shows that the average improvement of post-test scores was significantly higher than that of pre-test scores, with an average improvement of 42.25 points. The variation in scores decreased from the pre-test to the post-test, indicating increased consistency after the intervention.

Table 2. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pretest & Post-test	20	0.430	0.058

Source: Research 2024

Although there was a moderate correlation between Pre-test and Post-test scores, **Table 2** showed this relationship was not statistically significant (p=0.058, p=0.058). This may indicate that the increase in Post-test scores was likely more influenced by other factors, such as the intervention or treatment, than by a direct relationship with Pre-test scores.

Table 3. Paired Samples Test

		Paired Differences				
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	
					Lower	Upper
Pair 1	Pretest – Post-test	-42.250	10.192	2.279	-47,020	-37,480

Source: Research 2024

Table 3 showed the Post-test score was significantly higher than the Pre-test, with a mean difference of 42.25 points. The confidence interval range does not include the number 0, which means this result is statistically significant. This significant difference supports the claim that the intervention or treatment has a positive impact on improving performance.

Table 4. Paired Samples Test

	t	df	Sig. (2-tailed)
Pre-test – Post-test	-18,538	19	0.000

Source: Research 2024

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Mean Difference of -42.250. **Table 4** showed a negative difference, indicating increased results from the pretest to the post-test. T-value of -18.538, with df = 19. Significance (2-tailed): 0.000, which is less than 0.05.

Discussion

The paired sample t-test results indicate a significant disparity between the pretest and post-test outcomes of student learning. The mean pretest score was 38.75, with a standard deviation of 11.107, whereas the mean post-test score rose to 81.00, accompanied by a standard deviation of 6.609. The average increase of 42.25 signifies enhanced student learning outcomes following the intervention. The statistical test yielded a t-value of -18.538, with 19 degrees of freedom and a significance level of 0.000, below the significance limit of 0.05. Thus, it can be concluded that the method or intervention applied has a significant influence on improving student learning outcomes. A notable disparity exists between the pre-test and post-test scores, with the post-test group regularly achieving higher scores than the pre-test group, indicating that the intervention or treatment had a real effect. Thus, MOOCs interventions conducted before the Post-test were proven effective in improving participant performance. The study demonstrates a significant difference between the pre-test and post-test results, signifying the intervention's efficacy. The post-test group regularly attained superior results relative to the pre-test group, indicating a significant enhancement in participant performance. The significant rise in post-test scores demonstrates that the intervention, namely the MOOCs administered before the post-test, positively impacted student learning outcomes.

The efficacy of MOOCs in this context underscores their potential as a formidable instructional instrument. The enhancement noted in the post-test results indicates that the MOOCs intervention facilitated a deeper comprehension of the subject and improved participants' capacity to apply knowledge. MOOCs, characterized by their flexible and accessible learning forms, allow students to engage with expertise more actively and self-directedly. This may result in enhanced knowledge retention and improved ideas mastery, as seen by the substantial increase in scores. Moreover, the utilization of MOOCs underscores the prevailing trend toward digital and online learning platforms, which are progressively becoming essential to contemporary education systems. MOOCs include a variety of learning resources, including video lectures, interactive activities, and peer conversations, accommodating different learning styles and enhancing individualized instruction. This versatility is advantageous in heterogeneous classroom environments, as students exhibit differing prior knowledge and learning preferences (Giasiranis & Sofos, 2020).

This study indicates that MOOCs might significantly contribute to bridging educational disparities, especially in disciplines such as natural sciences, which frequently require specialized knowledge and practical experience. MOOCs possess the capacity to democratize education and enhance learning chances for students globally by delivering scalable, high-quality educational content to a broad audience. This study's favorable influence on student learning outcomes reinforces the increasing acknowledgment of MOOCs as a legitimate and effective alternative to conventional educational methods. The results underscore the importance of incorporating digital technologies in education, demonstrating that MOOCs enhance academic achievement while cultivating lifelong learning abilities, critical thinking, and self-directed learning. By utilizing learning media that is more interactive and flexible, this research assists students in improving their learning outcomes (Danka, 2020). This research also enables students to learn anywhere they choose. Students may participate more actively in the learning process and use technology intelligently to enhance their independent study (Budyastuti & Fauziati, 2021).

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The research allows educators to present educational content through a wider variety of media that is more appealing to students. To overcome traditional learning difficulties, teachers can employ MOOCs as an alternative. This is especially helpful in enhancing students' interest in studying, directly affecting their learning outcomes and motivation. Since it can reach a larger audience from various sectors, creating a MOOCs platform has been regarded as having significant potential for the education sector (Jung & Lee, 2020). MOOCs built on gamification and learning analytics provide learning experiences that are more engaging, personalized, interactive, and community-oriented (Ewais & Samara, 2020). MOOCs students should be well-informed initially, then should be delivered dynamically to maintain student motivation and provide relevant assessment (Sutisna et al., 2024). Additionally, educators have improved their ability to use technology effectively as a learning tool among their students. Additionally, schools can benefit from this research by utilizing it to assist their attempts to enhance the quality of education by implementing creative and technology-based learning multimedia. MOOCs will assist educational institutions in being more flexible in response to technological advances. Students' overall learning outcomes can be improved through MOOCs, which are accessible whenever and wherever students are.

CONCLUSION

The MOOCs implemented have substantial and significant effectiveness in increasing students' learning outcomes, notably in the subject of natural science. It is abundantly evident that the intervention successfully improved the student's performance, as seen by the considerable increase in post-test scores compared to the pre-test ratings. MOOCs have a good impact on education because they provide students with a learning experience that is adaptable, interactive, and readily available. As a result, students' comprehension of the material has considerably improved. The findings suggest that MOOCs have the potential to play a significant part in enhancing academic attainment, particularly in fields that call for more in-depth engagement and critical thinking. By offering learning solutions that are both scalable and innovative, MOOCs provide an excellent instrument for promoting student learning and developing long-term educational growth in disciplines that are crucial for the advancement of scientific and technological fields. As a recommendation for further researchers to investigate the use of MOOCs in other academic fields, particularly those that need in-depth knowledge and critical thinking, such as natural science, they should consider these possibilities. Combining MOOCs and more conventional instructional approaches can provide a more comprehensive educational experience. It is possible to significantly improve students' learning experiences by providing timely feedback on their progress and offering support through peer networks or instructors. Students can identify areas where they need development and maintain their engagement throughout the course with regular assessments and mentoring. Future research can develop MOOCs for language materials for primary students.

AUTHOR'S NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors also affirm that the data and content of this article are completely free of plagiarism, with all information presented having been ethically obtained and originally written. Any quotations or references from other works have been properly acknowledged and cited following applicable academic standards. The authors are committed to maintaining scientific and ethical integrity at every stage of the research and writing of this article.

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