Journal Evaluation in Education (JEE)
Vol. 6, No. 3, July 2025, pp. 916~923
ISSN: 2716-4160, DOI: 10.37251/jee.v6i3.1630

Needs Analysis for Developing Interactive Learning Resources Assisted by Geogebra Through the Spada Unismuh Learning Management System to Improve Students' Mathematical Visualization Skills

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Article Info

Article history:

Received Apr 04, 2025
Revised Jun 02, 2025
Accepted Jul 28, 2025
OnlineFirst Jul 31, 2025

Keywords:

GeoGebra
Mathematics
SPADA
Students

ABSTRACT

Purpose of the study: This study aims to analyze the need for developing GeoGebra-assisted interactive learning resources integrated into the SPADA Learning Management System to improve students' mathematical visualization skills.

Methodology: The study involved 29 lecturers from the Mathematics Education Study Program at Universitas Muhammadiyah Makassar. A questionnaire was used to gather data on first-year undergraduates needs regarding GeoGebra-based learning resources in SPADA Learning Management System. Data analysis was quantitative using descriptive statistics and qualitative analysis for suggestions.

Main Findings: The study revealed that 83% of lecturers emphasized the importance of developing GeoGebra-assisted learning resources in SPADA Learning Management System to improve understanding of abstract mathematical concepts. Most lecturers were familiar with SPADA LMS, but the use of features for mathematical visualization was limited.

Novelty/Originality of this study: This study is the first to analyze the need to integrate GeoGebra into the SPADA Learning Management System in order to improve mathematics learning through interactive visual representations. This study expands knowledge by proposing an innovative approach to improve mathematical visualization, helping students better understand abstract concepts, and improving student learning outcomes in mathematics.

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1. INTRODUCTION

The digital transformation of higher education has driven fundamental changes in learning strategies, including how lecturers design teaching materials and how students access, understand, and reflect on knowledge. Particularly in mathematics learning, students' primary challenge is the ability to visualize abstract concepts that underlie mathematical theory and application [1], [2]. Mathematical visualization is an essential cognitive aspect that includes the ability to create, read, and interpret visual representations such as graphs, diagrams, and symbolic illustrations to understand concepts and solve mathematical problems [3], [4]. Mathematical visualization refers to the use of graphical representations and visual techniques to understand, explore, and communicate mathematical concepts and problems. It involves the process of turning abstract mathematical ideas, such as equations, geometric shapes, or complex structures, into visual forms like graphs, charts, geometric figures, or interactive simulations [5]. Integrating visual aids such as Geogebra and digital

learning platforms such as Learning Management Systems (LMS) is an important need, especially in mathematics learning. LMS is a software platform or tool used to plan, deliver, and evaluate the learning process [6]. LMS allows for the digital management of learning, whether for formal education or non-formal training [7].

As part of the effort to digitize learning in higher education, Universitas Muhammadiyah Makassar (Unismuh) developed and implemented the Unismuh SPADA LMS as an adaptation of the SPADA platform launched nationally by the Directorate General of Higher Education. Unismuh SPADA LMS is designed to support the implementation of online learning in a structured and integrated manner, allowing lecturers to deliver materials, conduct assessments, and build pedagogical interactions online [8]. However, in the context of mathematics learning, the use of SPADA Unismuh LMS is still not fully optimal, especially in providing interactive learning resources that can strengthen students' mathematical visualization aspects [9]. The need for interactive learning resources integrated into the Unismuh SPADA LMS and supported by visualization applications such as Geogebra is becoming increasingly relevant in encouraging the effectiveness of technology-based learning

The main problem in learning mathematics in the Unismuh Mathematics Education Study Program is students' low mathematical visualization ability. This is exacerbated by the limited digital learning resources in the Unismuh SPADA LMS, which are generally static and less responsive to student learning needs. The absence of interactive features that can stimulate conceptual understanding makes students have difficulty building connections between visual and symbolic representations in mathematical materials. In addition, limitations in integrating visualization software such as Geogebra into the LMS cause pedagogical opportunities that should be maximized to be neglected [10]. A standard solution to overcome these problems is to develop learning resources based on student needs analysis and utilize interactive visualization technology [11].Needs analysis is a systematic approach to identifying gaps between current learning conditions and expected ideal conditions. By analyzing the specific needs of students in terms of content, learning media, and delivery methods, lecturers can design learning resources that are more relevant, adaptive, and contextual. Some studies show that using visual technology such as Geogebra in mathematics learning can improve concept understanding and mathematical visualization skills [12], [13] stated that students who learned using Geogebra significantly increased in constructing meaning from function graphs and geometry. Geogebra in problem-based learning activities can stimulate students' visual and spatial thinking skills [14]-[16]. Geogebra, as open-source software, provides an interactive environment that supports simultaneous symbolic and graphical representations, which is very effective for bridging the understanding of abstract concepts in mathematics [16]-[18].

In the context of online learning management, LMS has proven to be an effective solution in organizing and distributing teaching materials and enabling efficient communication between lecturers and students. LMS provides flexibility in accessing materials, automatic evaluation features, and supports the development of multimedia-based learning resources [19], [20]. The nationally developed SPADA LMS has been adopted by various universities, including Unismuh, and provides excellent opportunities for lecturers to create interactive and collaborative learning environments. Integrating applications such as Geogebra in the LMS opens up new possibilities for developing visual learning resources previously limited to local devices or standalone applications.

Furthermore, the approach to developing learning resources based on analyzing user needs has proven to produce more effective and appropriate products in the context in which they are used [21], [22]. Emphasize the importance of identifying learning needs as the basis for the instructional design process. Learning resource developers can design more targeted media by understanding students' characteristics, learning preferences, and the challenges they face in learning mathematics. Needs analysis also allows the identification of gaps in the existing learning system so that the proposed solutions can be more focused and significantly improve the quality of learning.

Many studies have examined the effectiveness of geometry in learning mathematics. Use of GeoGebra in mathematics learning is effective in improving students' mathematical visualization skills [23], [24]. In a systematic review conducted by [22], it was explained that GeoGebra creates an interactive learning environment that allows in-depth exploration of concepts and increases absorption of abstract mathematical material. However, these studies were generally conducted in the context of face-to-face learning without considering the potential for integration with the LMS used in online learning. [25], [26] added that Geogebra has excellent potential in supporting independent mathematics learning, but not many have explored how this application can be integrated into a learning management system such as SPADA. On the other hand, studies on the use of LMS in mathematics learning mostly focus on the managerial or technical aspects of the platform, not on the development of learning resources based on student needs [27], [28] highlight the importance of improving the quality of content in the LMS to attract students' interest in learning, but do not specifically examine the relationship between this content and mathematical visualization skills. The application of GeoGebra in learning management systems (LMS) to improve mathematical understanding, particularly in the concepts of geometry and functions [29]. Although these studies demonstrate the potential of GeoGebra in strengthening students' understanding, there remains a gap regarding the application of GeoGebra within the LMS context in Indonesia,

particularly on the Spada Unismuh platform. Thus, This research aims to address this gap by analyzing the needs related to the development of interactive learning resources based on GeoGebra within the Spada Unismuh LMS, with the goal of enhancing students' mathematical visualization skills in a more effective and contextual manner.

The novelty of this research lies in the strategic integration between the results of student needs analysis, the use of mathematical visualization tools such as Geogebra, and the Unismuh SPADA LMS learning platform. The learning resources developed will be based on a user-centered approach and designed to be adaptive to the actual needs of students in the context of modern mathematics learning. This research provides a scientific contribution in the form of a technology-based learning resource development model and needs analysis, which has not previously been the focus of many studies, especially in institutional LMS such as SPADA Unismuh. This study aims to analyze student needs for the development of Geogebra-based interactive learning resources integrated into the Unismuh SPADA LMS to improve mathematical visualization skills. The focus of the research is on systematically mapping student needs to design digital learning resources that are not only visually appealing but also effective in building understanding of mathematical concepts.

2. RESEARCH METHOD

This study used a survey research design to identify the needs of mathematics education study program students related to learning resources that can be developed on LMS SPADA assisted by Geogebra in learning mathematics. This research is an initial study of the development of Geogebra-assisted mathematics learning tools through LMS SPADA aims to increase the involvement of students' understanding of mathematical concepts with learning resources that are more interesting and effective for students. There were 29 participants involved in this study. They were all lecturers in the mathematics education department of the faculty of teacher training and education at Unismuh Makassar.

The data collection instrument used in this study was a questionnaire designed to collect detailed information about the needs of students and the expectations of mathematics education lecturers for learning resources that are suitable for use on the SPADA LMS. This instrument was validated by two validators and consisted of 14 questions. The questionnaire includes several components, namely: Experience using SPADA LMS, experience using GeoGebra in learning, students' mathematical visualization skills, needs and expectations for the development of interactive learning media, lecturers' readiness to use GeoGebra-based learning media, obstacles in using GeoGebra and SPADA LMS, and suggestions and input for the development of learning media. The data collection process focused on identifying the needs of mathematics education students and lecturers for appropriate learning resources on the SPADA LMS that allow students to better understand mathematical concepts when they study independently. Data from the results of the lecturer's response through the questionnaire became the basis for developing learning resources in accordance with student needs. The data used in this study were analyzed quantitatively using descriptive statistics and responses in the form of suggestions and input were analyzed using qualitative. This study involves lecturers from the Mathematics Education Department at Universitas Muhammadiyah Makassar as respondents. By selecting such a specific sample, there is potential for bias that needs to be considered. One potential bias is sample bias, which arises because the respondents are only from one university and one specific program of study. This can limit the generalization of the research findings to a broader context, especially beyond Universitas Muhammadiyah Makassar, or even outside the Mathematics Education Department.

3. RESULTS AND DISCUSSION

The needs analysis of developing AR-assisted interactive learning resources using LMS SPADA in learning mathematics aims to collect as much information as possible about the problems in learning resources that are suitable for use in learning mathematics on LMS SPADA.

3.1 Utilization Of LMS SPADA in the Learning Process

The results of research related to the utilization of LMS SPADA in learning specifically for lecturer respondents show that of the 29 involved, 68.9% of lecturers who have used LMS SPADA in the learning process of mathematics, and as many as 31.1% who have not used LMS SPADA in learning. The following is presented in Figure 1, which shows the percentage of lecturers who have utilized LMS SPADA.

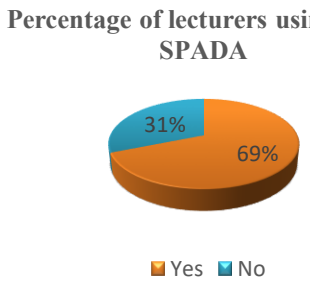

Figure 1. Lecturer presentation using LMS SPADA

Based on Figure 1, it is evident that the percentage of lecturers using the SPADA LMS is in the high category, meaning that 20 lecturers have used the SPADA LMS in their courses, while only around 9 have not used the SPADA LMS in their teaching activities. This indicates that most lecturers in the mathematics education department are familiar with the tools used in the SPADA LMS and have the potential to further explore and develop learning activities by utilizing other applications.

Using LMS SPADA in learning mathematics with Hybrid Flipped learning facilitates the learning process rather than using various platforms. The SPADA LMS has provided tools to develop multiple learning resources that can be accessed by students when not doing face-to-face learning or can access and study the course earlier through the SPADA LMS so that they can increase their repertoire of knowledge through various learning resources provided by lecturers on the platform. Unismuh SPADA LMS provides complete tools that can be used to create learning resources, activities, and assessments in one platform. The following figure 2 presents the percentage of SPADA LMS tools that mathematics education lecturers have used.

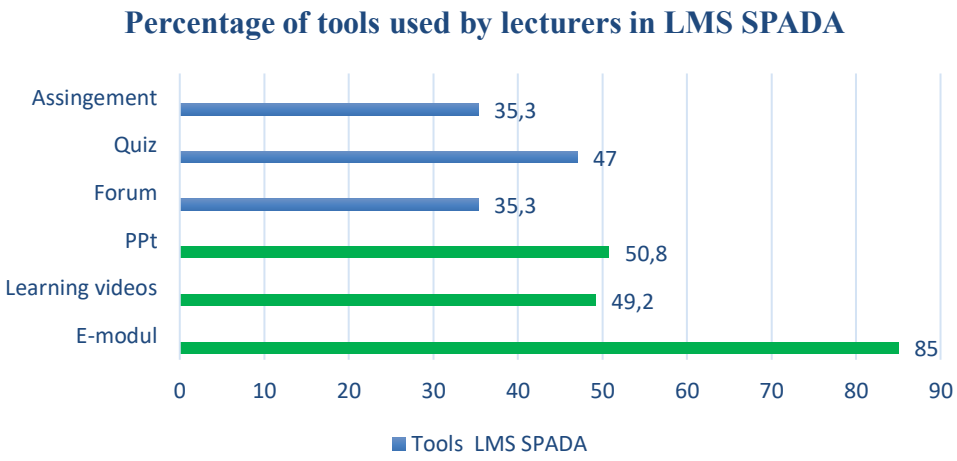

Figure 2. Percentage of tool usage on LMS SPADA

Based on the picture above, the learning resource tools that lecturers on LMS SPADA often use are PPt, Learning Videos, and E-modules. However, in developing learning resources, both lecturers on the LMS SPADA platform are still limited to theory, so it is not enough to maximize students' ability to understand mathematical concepts, especially in mathematics learning that requires mathematical visualization. Some input and suggestions recorded in the respondent's open-response questionnaire found that the learning resources currently developed are insufficient to provide students with visualization understanding, especially those related to geometry, calculus, and others. Therefore, instructors require templates that can address these issues, one of which is the Geogebra application, which can be directly integrated into the Learning Management System.

3.2 The Need for Geogebra-Assisted Learning Resources on the SPADA LMS

The availability of interactive learning resources is needed in learning mathematics. Learning resources that utilize the Geogebra application can facilitate students in visual representations such as graphs, diagrams, and symbolic illustrations. The results of the analysis of the lecturer's questionnaire on learning resources using Geogebra are presented in Table 1 below:

Table 1. Percentage of lecturer response results to learning resources using Geogebra

Statements	Respons (29 respondens)	Percentage (%)
Lecturer recognizes Geogebra Application	Yes	65.5
	No	34.5
Lecturers have used Geogebra to develop	Yes	13.8
learning resources	No	86.2
Lecturers know the benefits of using	Yes	37.9
Geogebra in learning mathematics	No	62.1

The data above shows that around 65.5% of teachers know about Geogebra, but their experience using Geogebra in developing learning resources is still around 13.8%. The causes of this gap are attributed to several factors, including a lack of understanding about the benefits of GeoGebra. Although lecturers are aware of GeoGebra, they may not fully grasp how this tool can enhance the quality of mathematics education, particularly in aiding the visualization of abstract concepts. Visualization of abstract concepts is usually found in calculus, geometry, and function graphs. Additionally, time and resource constraints may lead instructors to feel that using GeoGebra requires extra time to prepare materials, as well as the need for supporting infrastructure, such as hardware and stable internet access. Solutions that can be implemented to address this gap include: Providing training or workshops for instructors to teach the use of GeoGebra and provide concrete examples of how the tool can be used in mathematics instruction. Additionally, providing easier access and adequate devices such as the SPADA LMS that can be directly connected to the GeoGebra application.

In addition, although based on the percentage of lecturers who have experience using Geogebra is still small, it does not mean that lecturers do not want to use Geogebra in their learning, because it is proven from the results of data analysis related to lecturers' responses regarding the importance of learning resources using Geogebra packaged in SPADA LMS provides information that learning resources like this are important to be developed immediately, which aims to provide students with learning resources that can improve mathematical visualization.

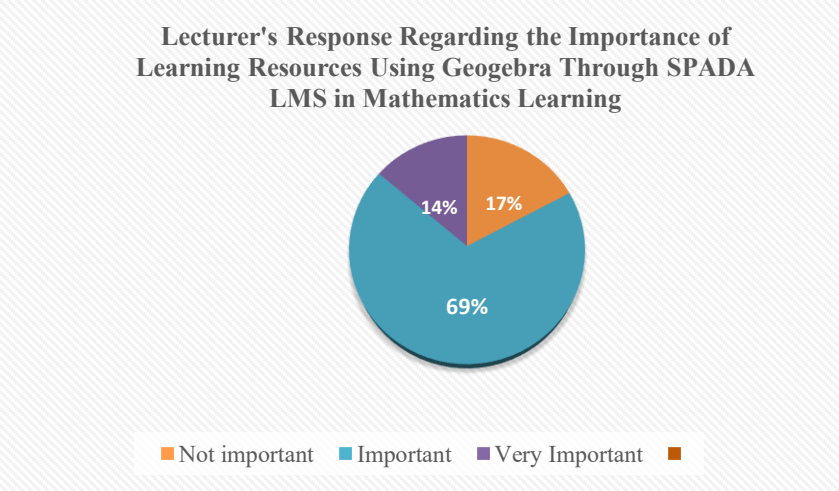

Figure 3. Lecturer responses regarding the importance of Geogebra-assisted learning resources through LMS SPADA in learning Mathematics

Based on Figure 3, the majority of lecturers (69%) stated that GeoGebra-assisted learning resources through the SPADA LMS in mathematics learning are important. Another 14% considered them very important, bringing the total to 83% of lecturers who believe such resources are important. Only 17% indicated that they are not important. These results suggest that most lecturers support the development of GeoGebra-based learning resources to enhance the effectiveness of mathematics instruction.

In mathematics education, students often face a high cognitive load when material is presented solely in symbolic or textual form. However, according to Sweller's Cognitive Load Theory, learning is more effective when the cognitive load received by students does not exceed their capacity [30]. Therefore, the use of visual representation media such as GeoGebra, which allows simultaneous graphical and symbolic displays, can reduce cognitive load. By combining visual and symbolic representations, students can access two different information channels (visual and verbal channels), in line with the dual coding theory proposed by Paivio. The dual coding theory explains that information presented through both visual and verbal representations simultaneously is more effective than using only one type of representation [30]. In the context of mathematics learning, the visual representations provided by GeoGebra enable students to visualize abstract concepts, such as function graphs,

geometry, and calculus. In this way, GeoGebra strengthens students' understanding of mathematical concepts that are difficult to grasp through verbal or symbolic explanations alone.

Previous research has shown that visual aids such as GeoGebra can improve students' visualization skills and their understanding of mathematical material [14], [16]. GeoGebra allows for simultaneous graphical and symbolic representation, which is essential in learning abstract mathematical concepts [17], [29]. The importance of integrating technology into mathematics education is also emphasized by other research, which shows that the use of GeoGebra in problem-based learning can stimulate students' visual and spatial thinking skills [14]. In this context, the SPADA LMS platform offers a suitable platform for integrating GeoGebra, enabling instructors to design interactive learning resources that respond to students' needs. SPADA LMS not only supports the distribution of learning materials but also provides features that can be used to add visualization applications such as Geogebra, which can significantly enhance students' learning experiences [20].

Although the benefits of using Geogebra have been widely proven in face-to-face learning, there is still a gap in research exploring the integration of Geogebra into LMS, especially in online learning. Research by [31]-[34] highlights the significant potential of GeoGebra in supporting self-directed mathematics learning. However, little has been explored on how this application can be integrated into LMS platforms like SPADA. This study addresses this gap by examining the needs and potential for integrating GeoGebra into the SPADA LMS at Unismuh to enhance students' mathematical visualization.

To effectively integrate GeoGebra into mathematics learning, we propose the use of a blended learning model that combines face-to-face learning with online learning through the SPADA LMS. In this model, face-to-face learning sessions can be used to provide basic explanations of mathematical concepts, while online sessions can focus on using GeoGebra to deepen students' understanding through independent exploration and practice. GeoGebra will be used in problem-based learning, where students can work with the application to solve mathematical problems related to graphs, geometry, and functions, while accessing materials and exercises through the SPADA LMS.

Additionally, the flipped classroom model can be an effective approach for integrating GeoGebra. In this model, students learn the basic material through instructional videos or reading materials uploaded to the SPADA LMS before class meetings. Class time is used to delve deeper into the topic by using GeoGebra to solve mathematical problems interactively, engage in group discussions, and ask questions. This will enable instructors to focus more on solving complex problems and deepening students' understanding of abstract concepts. By adopting a blended learning model or flipped classroom that integrates GeoGebra, it is hoped that students' mathematical visualization skills will improve, facilitating a more effective understanding of abstract concepts and providing a more interactive and engaging learning experience [35]-[40]. This approach can improve the quality of mathematics learning at Unismuh, make the learning process more responsive to students' needs, and help students overcome difficulties in understanding complex mathematical concepts.

4. CONCLUSION

Based on the analysis of the need for developing Geogebra-assisted learning resources through LMS SPADA, although most lecturers have used LMS SPADA, features that support mathematical visualization are still limited. Geogebra-assisted learning resources are needed to improve students' mathematical visualization skills, with 83% of lecturers supporting their development through LMS SPADA. Geogebra integration in LMS SPADA can enhance understanding of abstract mathematical concepts and stimulate students' visual and spatial thinking skills. Therefore, developing Geogebra-assisted learning resources in LMS SPADA significantly improves the quality of mathematics learning and increases the effectiveness of learning at Unismuh.

ACKNOWLEDGEMENTS

Thank you to all colleagues and stakeholders who have permitted and provided input on this research, so that researchers can complete this research to completion.

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