

The Integration of Multimedia in Higher Education Mathematics Instruction: Perceptions of Pre-Service Teachers

Integrasi Multimedia dalam Pengajaran Matematik di Pengajian Tinggi: Persepsi Guru Pelatih

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Abstract: The advancement of technology has urged all teachers to use technology in teaching, particularly difficult subjects like mathematics. However, the diverse backgrounds applied result in varying guidance and insights on teaching and learning, despite the common use of multimedia in mathematics education. This study highlighted some important factors in determining an effective mathematics lesson using multimedia. This study employed a correlational research design to collect quantitative data. A total of 200 preservice teachers from a public university participated in this study. A questionnaire was constructed to gauge the preservice teachers' perceptions of their lecturers' use of multimedia in teaching mathematics. The regression analysis showed a significant relationship between the factors of use of multimedia (namely guidance and preparation) and the perceived effectiveness of multimedia. The model is significant with R square of 'value' 26.4%, indicating the 26.4% of variance in "perceived effectiveness of multimedia" is explained by the two dimensions (guidance and preparation) in "perceived use of multimedia.". This study suggests universities should organise a mentor-mentee programme for pre-service teachers' improvement of using multimedia as an instructional strategy in teaching mathematics while they have more other preparation, such as skills of designing instruction.

Keywords: multimedia, mathematics, higher education, pre-service teacher;

Abstrak: Kemajuan teknologi telah menggesa semua guru menggunakan teknologi dalam pengajaran, khususnya mata pelajaran yang sukar seperti matematik. Walau bagaimanapun, latar belakang kepelbagaian yang diterapkan telah menghasilkan panduan dan pandangan yang berbeza-beza tentang pengajaran dan pembelajaran. Maka, kajian ini menyetengahkan beberapa faktor penting dalam menentukan pengajaran matematik yang berkesan dengan menggunakan multimedia. Kajian ini menggunakan reka bentuk kajian korelasi untuk mengumpul data kuantitatif. Seramai 200 orang guru pelatih dari sebuah universiti awam telah menyertai kajian ini. Satu soal selidik telah dibina untuk mengukur persepsi guru pelatih terhadap penggunaan multimedia pensyarah mereka dalam pengajaran matematik. Analisis regresi menunjukkan hubungan yang signifikan antara faktor penggunaan multimedia (iaitu bimbingan dan persediaan) berdasarkan persepsi terhadap keberkesanan multimedia. Model ini penting dengan nilai R-square sebanyak 26.4%, menunjukkan 26.4% varian dalam

"persepsi terhadap keberkesanan multimedia" dijelaskan oleh dua dimensi (panduan dan penyediaan). Kajian ini mencadangkan bahawa universiti perlu menganjurkan program mentor-mentee untuk penambahbaikan guru pelatih dalam menggunakan multimedia sebagai strategi pengajaran dalam pembelajaran matematik di samping mempunyai lebih banyak persediaan lain, seperti kemahiran mereka bentuk pengajaran.

Kata kunci: multimedia, matematik, pendidikan tinggi, guru pelatih;

Introduction

Mathematics is a complex subject, and many mathematical concepts are not directly comprehensible. The complexity of the task is due to the deep linkages between different mathematical concepts, necessitating detailed explanations to reveal the underlying links (Yang et al., 2021). Therefore, educators should utilise a variety of appropriate pedagogical methods to actively involve students (Bani Irshid et al., 2023; National Council of Teachers of Mathematics, 2020). Multimedia is identified as a useful teaching aid that eases the teaching and learning process (Abdulrahman et al., 2020). Nevertheless, there are factors that influence the effectiveness of using multimedia in terms of performance. Given the complexity of mathematical concepts, incorporating multimedia into the mathematical process may necessitate specific approaches. Hence, it is crucial to investigate to what extent multimedia influences the satisfaction of learning an abstract subject. This study aimed to identify preservice teachers' perceptions of the use of multimedia in learning mathematics.

Literature Review

Multimedia, recognised for its wide array of integrated resources (Abdulrahman et al., 2020; Guan et al., 2018; Tobolcea, 2013), including text, images, software, music, videos, and interactive content, has emerged as a vital resource in contemporary education. These resources and sophisticated instructional aids empower educators to help pupils develop solid conceptual comprehension while teaching complex mathematical ideas (Arroyo et al., 2014; Hwang et al., 2023). As a result, multimedia has opened up new possibilities for developing classroom mathematics teaching and learning.

The incorporation of multimedia enhances the understanding of complicated mathematical ideas and fosters a more captivating and immersive learning

environment and procedure, thereby facilitating the knowledge of mathematical concepts. Reducing the cognitive load of complex learning (Apostolou & Linardatos, 2023) provides a clear explanation. The efficiency of learning directly results in time savings by avoiding the lengthy procedure of obtaining comprehension. Therefore, multimedia facilitates the process of learning mathematics, which requires additional effort. The term "effort" refers to the collective impact of various factors, including cognitive, behavioural, motivational, emotional, social, and environmental components (Ellen L. Usher & Schunk, 2017).

A wide range of tools are essential for enhancing the learning process, and multimedia is especially vital for some individuals, such as those with visual impairments (Othman et al., 2023). Although there is compelling evidence that multimedia has a beneficial effect on students' mathematics performance, the majority of available studies concentrate on secondary school students (Akinoso, 2018) and elementary school students (Molina et al., 2018). Due to the focus on heavy conceptual comprehension in higher education mathematics, there is an increasing acknowledgment of the necessity to incorporate visualisation methods. However, it is crucial to acknowledge that the educational approach at the university level, specifically for pre-service teachers, may vary from that at primary and secondary schools. The perspectives of pre-service teachers serve as a guide for their further education in preparation for teaching in schools.

Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2009) offers a comprehensive framework that effectively elucidates the substantial impact of multimedia on learning outcomes. This theory addresses the cognitive fundamentals that underpin the process of learning across numerous forms of media. It highlights the interaction between several forms of media, including visual, computer simulation, interactive display, and audio elements, in order to enhance the processing and retention of information. The relationship between instructional

materials, multimedia design, and learners' cognitive psychology has a significant impact on learning outcomes (Mayer, 1994). Alignment plays a vital role in mathematics education by minimising cognitive effort throughout various mathematical processes, such as making connections, communicating information, representing, reasoning, and solving problems (Paas & Van Merriënboer, 1994; Zhu & Simon, 1987). The argument suggests that while multimedia presentations offer benefits in education, only carefully created multimedia resources, including visuals, succinct text, and synchronised classroom communication, effectively boost understanding and knowledge retention. As a result, the process of improving the use of multimedia necessitates additional input from educators to help them create effective and engaging learning experiences using this essential medium.

The goal of incorporating multimedia into education is to address students' learning needs and facilitate comprehension of challenging mathematical concepts within a limited timeframe. Consequently, educators must explore innovative ways to integrate multimedia tools and technology into their teaching practices. Figure 1 delineates the required efforts for the effective and meaningful application of multimedia in mathematics learning. Educators subsequently gauge the success of this integration based on its impact on learning ease, environmental enhancement, and time efficiency.

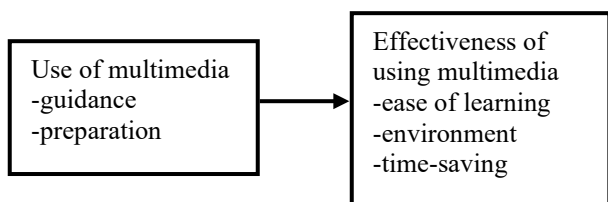


Figure 1. A framework

Materials and method

Research Design

This study employed a correlational research design to collect quantitative data for the investigation of the relationship between the use of multimedia and the effectiveness of using multimedia for the teaching of mathematics.

Sampling

The sampling was conducted based on volunteer sampling from a population that consisted of pre-

service teachers at a public university. The inclusion criteria were pre-service teachers who are capable of teaching mathematics and the exclusion criteria were those who did not agree on participation. A total of 200 preservice teachers participated in this study.

Instrumentation

A questionnaire was constructed to gauge the pre-service teachers' perceptions of their lecturers' use of multimedia in teaching mathematics. A set of existing questionnaires (Abari & Ayila, 2021; Mahir et al., 2021; Rasul et al., 2011) measuring teaching aids for the teaching was adapted to this study. Two experts validated the constructed questionnaire, and some modifications were made to improve the assessment. Then, a pilot test was conducted, and the results showed that the items' reliability (Cronbach's alpha) in the dimensions of "use of multimedia" and "effectiveness of multimedia" were 0.914 and 0.933, respectively.

Result and Discussion

Table 1 illustrates the perceived use of multimedia in their lecturers' practice. They rated the two dimensions: guidance (mean = 4.02; standard deviation = 0.58) and preparation (mean = 3.90; standard deviation = 0.62). The cumulative assessment of the use of multimedia for the teaching of mathematics yielded a moderately high overall rating with a mean of 3.99 and a standard deviation of 0.56.

Table 1. Use of multimedia as perceived by pre-service mathematics teacher.

Dimension	Item	Mean	Std. Deviation
Guidance	1 Most of my mathematics lecturers use multimedia in teaching mathematics.	4.11	0.73
	2 Most of my mathematics lecturers use multimedia related to their teaching topic.	4.01	0.73
	3 Most of my mathematics	4.10	0.73

		lecturers use multimedia in sequence according to the flow of the lesson.			
	4	The multimedia is used according to the student's level.	3.95	0.76	
	5	Most of my mathematics lecturers use multimedia according to students' needs.	4.02	0.77	
	6	Most of my mathematics lecturers explain the concept clearly to students by using multimedia.	4.06	0.70	
	7	Most of my mathematics lecturers guide their students to use multimedia properly.	3.92	0.70	
Overall dimension guide			4.02	0.58	
Prepa	8	Most of my mathematics lecturers prepare his/her multimedia before the classroom.	3.97	0.75	
ration	9	Most of my mathematics lecturers are experts in using multimedia.	3.83	0.69	
Overall dimension preparation			3.90	0.62	
Overall result on respondent perceptions on their lecturers' usage of multimedia in teaching mathematics			3.99	0.56	

Table 2 shows the perceived effectiveness of incorporating multimedia in tertiary mathematics classes across three dimensions: ease of learning (mean = 4.19; standard deviation = 0.54), learning environment (mean = 4.22; standard deviation = 0.56), and time-saving attributes (mean = 4.19; standard deviation = 0.70). The cumulative assessment of multimedia effectiveness yielded a high overall rating, with a mean of 4.20 and a standard deviation of 0.53.

This collective rating underscores a consensus

among respondents regarding the advantageous role of multimedia, affirming its utility in enhancing comprehension of mathematical concepts. The inclusion of multimedia not only facilitated a more enjoyable classroom learning experience, but also expedited the pace at which students grasped complex mathematical ideas.

Table 2. Effectiveness of using multimedia as perceived by pre-service mathematics teacher.

Dimension	Item	Mean	Std. Deviation
Ease the learning	1 The multimedia makes learning effective.	4.24	0.67
	2 The multimedia assists in explaining difficult math concepts in a simple way to understand.	4.22	0.69
	3 Multimedia plays an important role in a student's learning.	4.14	0.73
	4 The use of multimedia helps improve students' understanding of the lesson content.	4.22	0.69
	5 The multimedia provides help to students in different assignments.	4.14	0.68
	6 Teaching with multimedia with pictures, graphics and explanations made it easy for me to understand.	4.33	0.69
	7 In the lessons	4.18	0.64

		using multimedia, I think that I got enough information from the instructors who were doing the activity.		
	8	Lessons using multimedia helped me to find and define the problems and issues in my learning.	4.06	0.72
Overall dimensions ease the learning			4.19	0.54
Environment	9.	Use of multimedia brings change in the classroom environment.	4.16	0.71
	10.	Multimedia. make learning enjoyable.	4.29	0.67
	11.	Because the multimedia learning environment is supported with audio, video and animation, my learning performance increased.	4.21	0.64
Overall dimensions environment			4.22	0.56
Save time	12.	The multimedia saves student's time in understanding the content of the lesson.	4.19	0.71
Overall dimensions save time			4.19	0.70
Overall result on respondent perceptions on perceived effectiveness of using multimedia in			4.20	0.53

teaching mathematics

Table 3 presents the correlation between the perceived effectiveness of multimedia usage and the perceived use of multimedia. The analysis revealed a moderate relationship, with a correlation coefficient of 0.508 at a significance level of $p < 0.01$. This moderate correlation indicated that the use of multimedia in tertiary mathematics education was moderately associated with perceived effectiveness, specifically in terms of facilitating ease of learning, enhancing the learning environment, and saving time in the learning process. The findings underscored the potential positive impact of multimedia tools on the overall learning experience in the teaching of tertiary mathematics instruction.

Table 3. Correlation between the perceived effectiveness of multimedia usage and the perceived use of multimedia

		Perceived Use of multimedia
Perceived Effectiveness	Pearson Correlation	0.508
	Sig. (2-tailed)	<0.01
N		200

Specifically, the regression analysis shows a significant relationship between the factors of use of multimedia (namely guidance and preparation) and the perceived effectiveness of multimedia. The model is significant since $F = 35.318197$ with $p < 0.01$. The R square is 26.4%, indicating the 26.4% variance in "perceived effectiveness of multimedia" was explained by the two dimensions (guidance and preparation) in "perceived use of multimedia." For the factors (Table 4) in "use of multimedia," both factors, namely "guidance" and "preparation," contribute almost exclusively equally to the "perceived effectiveness of multimedia," with coefficients of 0.284 and 0.208, respectively.

Table 4. Model of the perceived effectiveness

Model B	Unstandardized Coefficients	Standardized Coefficients	t	Sig.
		Std. Error Beta		
(Constant)	2.245	0.236	9.524	<.001
Guidance	0.284	0.088	3.229	0.001
Preparation	0.208	0.082	2.539	0.012

a. Dependent Variable: Effectiveness

Discussion

This study revealed that the pre-service teachers responded positively to the integration of multimedia in mathematics instruction, in accordance with their observations of their lecturers' teaching methods. The positive perceptions were evident in the positive ratings they assigned to the effectiveness of multimedia in the educational process.

The results showing positive ratings of effectiveness using multimedia have provided an opportunity for pre-service teachers to learn how to conduct lessons using multimedia successfully. This could provide them with an example for their future teaching in secondary school. Preservice teachers need multiple forms of guidance from mentors (Orland-Barak & Wang, 2021). In this study, the lecturers served as both mentors and educators. Even though the guidance contributed indirectly, which was based on their observations of their lecturers' teaching, they also believed that their mentors were presenting the right methods. Emulating lecturers' practices is a natural process for improving their skills (Singh et al., 2020).

Pre-service teachers undergoing training may benefit from more exposure to exemplary teaching practices. Observing the real success of lecturers influences participants' beliefs about the usefulness and ease of using technology, which in turn impacts their actual use in teaching (Davis, 1989). Such a highly rated instructional approach provides a valuable means of guidance for interpreting complex concepts in teaching mathematics to pre-service teachers. This knowledge is essential because preservice teachers require the necessary teaching knowledge, skills, experience, efficacy, professional development, and support for their learning (Hyseni Duraku et al., 2022). This aligned with the findings of previous studies that emphasised the significance of well-designed strategies and preparedness in using multimedia as pivotal elements in the development of mathematics education (Angraini & Hardi, 2023; Suri & Rachmadtullah, 2021; Yaftian & Barghamadi, 2022).

Furthermore, it outlined the reasons and factors that contribute to a positive impact on the teaching of mathematics. This has been exceptionally important since Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2009), which posits that the use of multimedia can enhance learning outcomes while ensuring that teachers put some effort into this matter.

According to Mayer's theory, multimedia learning is effective when it aligns with the cognitive processes of the learners' engagement. Multimedia tools in classroom instruction can cater to diverse learning styles and engage students in a multisensory manner, facilitating better understanding and retention of mathematical concepts since they simplify abstract concepts into concrete understanding (Abdulrahman et al., 2020).

This study has created awareness among pre-service teachers about today's advanced approach to teaching mathematics via multimedia tools and platforms. The study highlights the importance of focusing on complex topics that necessitate simulation, such as different types of graphs and their connections to functions and equations, as a crucial factor contributing to the positive influence on education (Joshi et al., 2023). The integration of multimedia resources has harnessed the advanced technology that makes the learning experience more enjoyable but also fruitful (Rebollo et al., 2022). Mayer's (2009), theory, which underscores the significance of graphical and visual representations in cognitive development, has significantly influenced the teaching and learning of mathematics.

Conclusion

In conclusion, this study demonstrates that pre-service teachers' favourable attitudes toward using multimedia in mathematics instruction align with Mayer's Cognitive Theory of Multimedia Learning. The successful incorporation of multimedia in the classroom setting was achieved by the diligent efforts, strategic planning, and preparation of educators. These actions were in line with concepts that maximise cognitive processing to improve learning results.

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