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The potential of interactive multimedia with contextual teaching and learning approaches in mathematics learning: a systematic literature review

Khairunnisa Hanan Pratiwi*), Robinson Situmorang, Tuti Iriani
Educational Technology Study Program, Faculty of Education, Universitas Negeri Jakarta, Indonesia

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ABSTRACT

This study aims to determine the potential and characteristics of interactive multimedia with an effective Contextual Teaching and Learning (CTL) approach in elementary school mathematics learning through a Systematic Literature Review (SLR). A total of 18 relevant studies were analyzed in this study, which consisted of journal articles published in 2013-2023. Scientific journals or conference proceedings are used indexed by Scopus Q1-Q4. The exclusion criteria in this article are articles that do not have a complete structure, review articles or conceptual articles that do not report the results of empirical research. The results of the analysis show that interactive multimedia with the CTL approach has great potential in improving the learning outcomes, motivation, engagement, and understanding of mathematical concepts of elementary school students. CTL allows students to see how mathematical concepts can be applied in everyday life, making the learning process more relevant and engaging. Characteristics of interactive multimedia with an effective CTL approach include the use of rich and relevant visuals to real-world contexts, interactivity that allows active exploration, authentic presentation of problems, constructive feedback, scaffolding that suits the needs of students, and the integration of elements of art and aesthetics. The implementation of interactive multimedia with the CTL approach also has challenges, such as the availability of technology infrastructure and teacher competence. This study implies that teachers and researchers need to realize that the design and use of interactive multimedia with the CTL approach can effectively improve the quality of mathematics learning in elementary school.

Corresponding Author:

Khairunnisa Hanan Pratiwi,
Universitas Negeri Jakarta
Email: hananpratiwi4@gmail.com

Introduction

Learning is a conscious effort made by teachers to help students learn according to their needs and interests (Asyaari, 2023). Educational content standards, including at the basic education level, are an important concern in many countries around the world. Mathematics as one of the mandatory contents in the basic education curriculum, plays a crucial role in the world of education globally (de Brito Lima et al., 2022; Määttä et al., 2022). Understanding mathematics is considered essential to understanding the world and phenomena around us (Määttä et al., 2022). Various international studies, such as (Mullis et al., 2009; and OECD, 2019 PISA (Programme for International Student Assessment), periodically measure students' mathematical ability in

various countries as an indicator of the quality of education (Määttä et al., 2022; OECD, 2019) The results of these studies are often used as a reference for education policymakers in many countries to evaluate and improve the curriculum, especially in mathematics learning. This shows that mathematics learning has become a global concern and continues to strive to improve its quality in order to equip the younger generation to face future challenges.

The scope of mathematical material, one of which is multiplication arithmetic operations that are carried out efficiently to solve contextual problems (Permendikbudristek, 2022). Learning multiplication is an important part of the elementary school curriculum as a foundation for mathematics (Fatayan et al., 2022) and become a provision to acquire further skills and conceptual understanding of the material (Milton et al., 2019). However, currently, mathematics learning has not used learning approaches and media that are close to students' daily lives (Abdulrahaman et al., 2020; Sanchez et al., 2018), so they are not interested in mathematics because it is considered irrelevant to real life (Setianing Putri et al., 2022).

This is evidenced by observation to one of the elementary schools in Jakarta, Indonesia, where around 40-50% of students have difficulty understanding the concept of multiplication. Students also have difficulty when working on problems in the form of stories given because they do not use a context that is close to them. In fact, the mathematical concepts taught, when related to daily life, can motivate students to solve certain problems with multiplication operations (T. H. Wang et al., 2021). Some of the findings are (1) students are enthusiastic when they are actively involved in learning, and (2) learning media has not used an approach that is close to the daily life of students (Tria Astika et al., 2019). Providing learning experiences on aspects of mathematics in the environment around students, can provide opportunities for them to understand mathematical relationships in the real world (Määttä et al., 2022) so that they are meaningful to students' lives (Marta et al., 2023).

Meaningful learning can be obtained by students by applying a contextual teaching and learning (CTL) approach (Marta et al., 2023; Okayanti & Semara Putra, 2021; Setianingrum et al., 2022). CTL actively engages students in learning by connecting the knowledge gained with real-life contexts (Agus, 2019; Gebre & Polman, 2020; Herdiyanti & Suparno, 2023; Okayanti & Semara Putra, 2021; Setyowati et al., 2023; Susanti & Wutsqa, 2020). The CTL approach emphasizes the connection of concepts with real life with the goal that students are able to find meaning from what they learn (Agus, 2019). In Permendikbudristek No. 16 of 2022 concerning process standards, learning strategies are implemented by optimizing available resources, as well as using information and communication technology (ICT) devices. One of the applications of ICT in learning is interactive multimedia ((Liana & Nursuhud, 2020). Interactive multimedia integrates various media elements. (Liana & Nursuhud, 2020; Sari et al., 2021)That can provide quick response or feedback. (Sari et al., 2021). The use of multimedia as a learning medium is highly recommended in learning. (Sawitri Pratiwi et al., 2020)Because it can put students as the center of learning (Arnindya Navitri Ainullah et al., 2023). The use of interactive multimedia in basic mathematics learning based on Contextual Teaching and Learning (CTL) is supported by various studies that show its positive impact on student understanding, engagement, and learning motivation. By combining interactive technology and contextual approaches, several studies have identified significant benefits for teaching abstract concepts in mathematics.

Previous research has found that interactive multimedia with collaborative learning approaches has a positive influence on learning. (Arnindya Navitri Ainullah et al., 2023; Liana & Nursuhud, 2020; Manurung & Panggabean, 2020). The use of interactive multimedia with a learning approach can increase interest in learning mathematics in elementary school multiplication materials. (Pratiwi, 2019). Other research related to the CTL approach has been shown to improve student learning outcomes. (Nuraeni et al., 2021; Purba et al., 2021; Setyowati et al., 2023). CTL focuses on the application of mathematical concepts in real situations. Thus, students can understand the practical value of mathematics and improve their problem-solving skills. CTL allows students to see how mathematical concepts can be applied in everyday life, making the learning process more relevant and interesting. Interactive multimedia allows students to interact directly with the subject matter, improving their problem-solving skills. By using simulations and interactive games, students can practice solving problems practically and effectively, in accordance with the principles of CTL. CTL and interactive multimedia can be combined to create a more comprehensive learning experience. By using interactive multimedia, CTL can be implemented more effectively, allowing students to see how mathematical concepts are applied in real situations through animations, videos, and simulations. The development of interactive multimedia with a contextual approach or CTL is effectively applied in learning (Buchori, 2019; Geni et al., 2020).

Based on the explanation above, previous research on interactive multimedia and Contextual Teaching and Learning (CTL) has shown many benefits, but there are still some shortcomings that have not been fully answered. Some aspects that have not been explored much in previous research, and how the Systematic Literature Review (SLR) research on interactive multimedia in the context of CTL can fill the veil with several points such as; most studies that examine the general benefits of interactive multimedia in education, but only a

few specifically explore its effectiveness in basic mathematics learning using the CTL approach. In addition, most studies focus on the use of multimedia in general in education, without exploring in depth how CTL as a pedagogical approach is integrated with interactive multimedia in improving understanding of basic mathematical concepts. The second point is that there are many studies that focus on interactive multimedia or CTL separately, without conducting deep integration between the two. Interactive multimedia is often used in a different context from the CTL principle, so there is less emphasis on contextual relevance and real-world applications, which are the core of the CTL approach. As a result, there is a lack of studies that really shine how CTL components (such as relevance to real contexts, active learning, reflection) are implemented in interactive multimedia. Although there has been previous research, there have not been many Systematic Literature Reviews related to the potential of interactive multimedia with the CTL approach in elementary mathematics learning. SLRs are conducted to identify, evaluate, and interpret all available and relevant research related to a particular research question (Kitchenham et al., 2009). The systematic literature review will involve analysis of a range of relevant research sources to identify the potentials and constraints of using interactive multimedia in mathematics learning. This will help in developing effective and evidence-based learning strategies, as well as understanding how interactive multimedia can be integrated with contextual learning approaches to improve the quality of mathematics learning.

Based on the gaps that have been presented, this study aims to evaluate the potential and characteristics of interactive multimedia with an effective CTL approach in elementary mathematics learning through a Systematic Literature Review. The results of this study are expected to provide an overview and recommendations for teachers, multimedia developers, and researchers in utilizing and developing interactive multimedia with an effective CTL approach to improve the understanding of mathematical concepts of elementary school students.

Method

This study uses the Systematic Literature Review (SLR) method which aims to identify, evaluate, and interpret all available and relevant research related to the potential of interactive multimedia with the Contextual Teaching and Learning (CTL) approach in elementary school mathematics learning. SLR is carried out by following the guidelines of Preferred Reporting Items for Systematic Reviews (PRISMA) (Moher et al., 2009) The number of selected articles can be seen in the Flow Prism Image 1.

The inclusion criteria used in this SLR are (1) Research articles published in scientific journals or conference proceedings indexed by scopus Q1-Q4; (2) Research that applies interactive multimedia with the CTL approach in elementary mathematics learning; (3) Research that reports on student learning outcomes, motivation, or involvement in learning; (4) Articles in Indonesian or English; and (5) Articles published in the 2013-2023 time frame, this is because interactive multimedia technology has developed rapidly in the last decade, especially after 2013, with advances in digital technology, educational software, and technology-based education. Newer research will be more relevant because it utilizes the latest technology in interactive multimedia. Meanwhile, the exclusion criteria include (1) Articles that do not have a complete structure (e.g., abstract only); (2) Review or conceptual articles that do not report the results of empirical research; and (3) Research that cannot be downloaded pdf. Search strategy: Article search is carried out on electronic databases, such as Science Direct using relevant keywords such as "interactive multimedia", "contextual teaching and learning", and "contextual approach".

The article selection process is carried out in two stages. First, articles are screened based on title and abstract to assess their suitability with inclusion and exclusion criteria. Second, articles that pass the initial screening are read in full to determine their feasibility. Two researchers independently conducted article selection and discussions were carried out to resolve differences of opinion until a consensus was reached. The data extracted from each article includes: author, year of publication, research objectives, research methods, sample characteristics, types of interactive multimedia used, application of the CTL approach, student learning outcomes, as well as advantages and disadvantages of interactive multimedia with the CTL approach used. The extracted data is then synthesized narratively to answer the research question. The findings of each article are grouped based on the same theme and analyzed descriptively according to the research question that has been written.

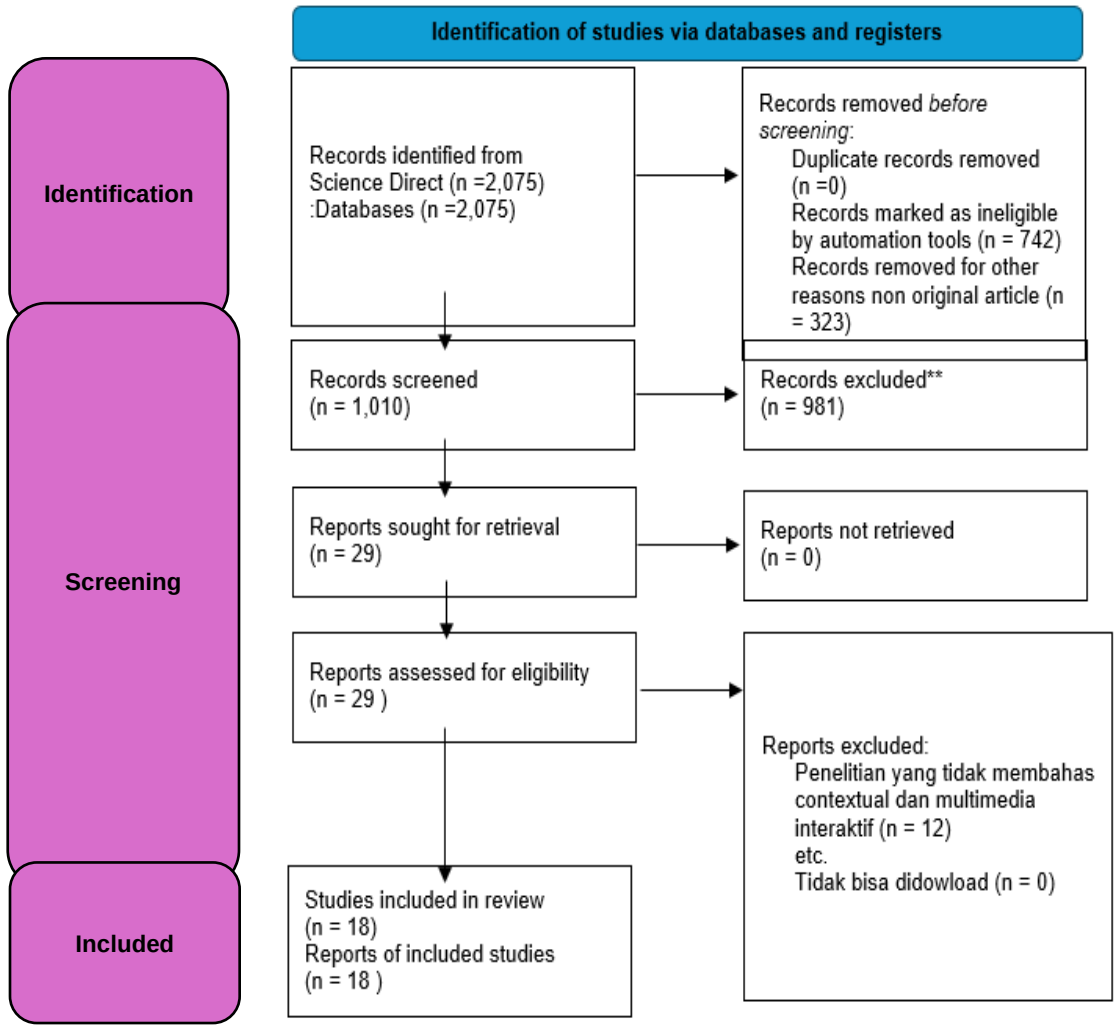

Figure 1 <Diagram Alir PRISMA Microlearning>

Based on the results of article selection by the inclusion and exclusion criteria, as many as 19 relevant studies were further analysed in this study. The studies consist of journal articles published in the 2013-2023 range. Most studies, i.e. about 80%, use experimental research methods, while the rest, about 20%, use classroom action and development research methods (Abdulrahaman et al., 2020; Sanchez et al., 2018). The research sample included elementary school students in grades 1 to 6, with the number of samples varying between 20 to 120 students per study. About 60% of studies involved samples with numbers between 20 and 50 students, while another 40% of studies used larger samples, i.e. between 50 and 120 students.

Mathematics subjects that are the focus of the research include multiplication operations (about 50%), geometry (about 30%), and problem-solving (about 20%) Some studies were conducted in Asian countries such as the Philippines. (Sanchez et al., 2018)Taiwan (Liu, 2023; Radu et al., 2023), and Indonesia (Buchori, 2019; Geni et al., 2020). These studies show that the use of interactive multimedia with the CTL approach is effective in improving learning outcomes and student engagement in mathematics learning. In addition, several studies have also been conducted in Western countries such as the United States. (Hwang et al., 2023)Europe (Algers et al., 2013; Tudor, 2013), and Africa (Benning & Davis, 2023), which reveals the potential of interactive multimedia in increasing students' motivation and understanding of mathematical concepts.

Although the included studies have diverse characteristics, such as geographic location, grade level, and math topics taught, the findings of the study consistently demonstrate the potential of interactive multimedia with the CTL approach in improving mathematics learning in elementary school. This indicates that the integration of interactive multimedia with the CTL approach can be a promising strategy to be applied in various contexts of mathematics learning at the elementary level.

Results and Discussions

The Potential of Interactive Multimedia with the CTL Approach

Analysis of the included studies found several potentials or benefits of using interactive multimedia with the CTL approach in elementary mathematics learning. First, most studies reported a significant improvement in mathematics learning outcomes in students who learned using interactive multimedia with the CTL approach compared to students who learned using conventional methods.(Abdulrahaman et al., 2020; Buchori, 2019; Geni et al., 2020; Shen et al., 2014). This improvement in learning outcomes includes understanding concepts, problem-solving skills, and numeracy skills. Second, several studies reveal that the use of interactive multimedia with the CTL approach can increase the motivation to learn mathematics in elementary school students. (Shen et al., 2014; Tapingkae et al., 2020; Tudor, 2013). Students show higher enthusiasm and interest in participating in math learning when using interactive multimedia that relates the material to a real-world context. Third, interactive multimedia with a CTL approach can increase student engagement in mathematics learning. (Abdulrahaman et al., 2020; Benning & Davis, 2023; Radu et al., 2023). Students become more active in exploring mathematical concepts, asking questions, and discussing with peers when using interactive multimedia that connects the material to their daily experiences. Finally, the CTL approach integrated in interactive multimedia helps students better understand mathematical concepts. (Buchori, 2019; Geni et al., 2020; Peng et al., 2022; Shen et al., 2014). The presentation of mathematical material associated with real-world contexts makes mathematical concepts more concrete and easy for students to understand. These findings show that interactive multimedia with the CTL approach has great potential in improving various aspects of mathematics learning in elementary school, ranging from learning outcomes, motivation, and involvement, to understanding mathematical concepts.

Characteristics of Interactive Multimedia with an Effective CTL Approach in Elementary Mathematics Learning

An analysis of the included studies revealed several key characteristics or features of interactive multimedia with the CTL approach that have proven effective in improving elementary mathematics learning. First, the use of visually rich multimedia such as images, animations, videos, and 3D components that are relevant to the student's real-world context (Abdulrahaman et al., 2020; Radu et al., 2023). Multimedia that presents objects or situations that are familiar to students helps them relate mathematical concepts to everyday experiences. Second, the existence of an element of interactivity that allows students to actively explore mathematical concepts, such as simulations, games, or interactive exercises related to real-world contexts (Buchori, 2019; Radu et al., 2023; Sung & Hwang, 2014). Third, the presentation of mathematical problems or challenges that are authentic and relevant to students' daily lives (Geni et al., 2020; Sung & Hwang, 2014; Tapingkae et al., 2020). The problems presented in the interactive multimedia should reflect the real situations that students may face in their daily lives.

Fourth, providing constructive and contextual feedback (Abdulrahaman et al., 2020; Benning & Davis, 2023). Effective interactive multimedia provides feedback that helps students understand their mistakes and provides clues or suggestions related to the context of the problem presented. Fifth, the existence of scaffolding or learning support in accordance with the level of student understanding (Er et al., 2013; Tapingkae et al., 2020). Interactive multimedia with an effective CTL approach provides support or assistance that can be tailored to the individual needs of the student, such as step-by-step instructions, relevant examples, or additional explanations. Finally, the integration of art and aesthetic elements in interactive multimedia with the CTL approach can increase student engagement and learning motivation (Liu & Wu, 2021; Peng et al., 2021). The use of art elements such as illustrations, animation, and engaging music can stimulate students' emotional experiences and increase their interest in math learning content.

The characteristics of interactive multimedia with an effective CTL approach include the use of visuals that are rich and relevant to real-world contexts (Abdulrahaman et al., 2020; Radu et al., 2023), interactivity that allows for active exploration (Buchori, 2019; Radu et al., 2023; Shen et al., 2014), an authentic presentation of the problem (Geni et al., 2020; Hwang et al., 2023; Tapingkae et al., 2020), providing constructive feedback (Abdulrahaman et al., 2020; Benning & Davis, 2023), scaffolding that suits the needs of students (Algers et al., 2013; Tapingkae et al., 2020), as well as the integration of artistic and aesthetic elements (Liu, 2023; Peng et al., 2022). These characteristics suggest that interactive multimedia with an effective CTL approach in elementary mathematics learning should be designed with the real-world context of students, provide interactive and authentic learning experiences, provide learning support tailored to student's individual needs, and integrate artistic and aesthetic elements to increase learning engagement and motivation. By paying attention to these characteristics, the development of interactive multimedia with the CTL approach can be more optimal in improving the quality of mathematics learning at the elementary level.

These findings provide a strong foundation for teachers, multimedia developers, and researchers to design and utilize interactive multimedia with the CTL approach in elementary mathematics learning. Nonetheless, further research is needed to explore the factors influencing the effectiveness of interactive multimedia with the CTL approach in a broader and more diverse context, as well as to identify optimal strategies for integrating these technologies into daily learning practices.

Challenges and Obstacles in the Implementation of Interactive Multimedia with the CTL

Approach There are various challenges and obstacles in the application of interactive multimedia in learning. Research written by Mustafa & Fatma (2013) explains that the lack of resources for technology integration in schools is an obstacle in the process of implementing interactive media. Many schools, especially in remote areas or on a budget, do not have enough computers, tablets, or other devices necessary to support multimedia-based learning. In addition, the cost of procurement of technology devices is often an obstacle because the education budget in many schools is very limited. Schools located in rural areas, do not have fast and stable internet access. Slow or limited internet access can hinder the interactive multimedia-based learning process. Fast and affordable internet is essential to support the use of technology and multimedia in the learning process. Lack of access to low-cost broadband internet can hinder the application of interactive multimedia, Difficulties in the use of modern teaching tools such as the suboptimal use of e-learning platforms and projects involving online research will be hampered (Benning & Davis, 2023).

Another problem behind the obstacles in the implementation of interactive multimedia is the lack of basic computer literacy skills among teachers (Abylkassymova, Akperov, Tuyakov, Ardabayeva, & Sydykova, 2024). This problem is a significant challenge in the application of interactive multimedia with the Contextual Teaching and Learning (CTL) approach (Mustafa & Fatma, 2013). Computer literacy is a fundamental skill needed to utilize technology and interactive media in the learning process. When teachers have low technological skills, teachers are less likely to be able to create multimedia-based teaching materials that are in accordance with the CTL approach, such as learning videos, interactive presentations, or online quizzes. This limits the variety of teaching methods that can be used (Radu, Yuan, Huang, & Schneider, 2023). Due to the limitations of computer capabilities, teachers are more likely to use traditional teaching methods, such as lectures or textbooks, which may not be adequate to support contextual approaches that demand more active student engagement. Teachers with low computer literacy are less likely to be able to create multimedia-based teaching materials that are compatible with the CTL approach, such as learning videos, interactive presentations, or online quizzes. This limits the variety of teaching methods that can be used (Deng, Benckkendorff, & Gao, 2022). Digital tools such as simulation applications, interactive learning software, or educational games that are relevant to the CTL approach are often overlooked because teachers do not know how to use them.

The CTL approach philosophically emphasizes contextual learning, meaningful, and based on students' needs and experiences (Deng, Benckkendorff, & Gao, 2022). However, in practice, various factors often lead to inconsistencies between these principles and the application of interactive multimedia in the classroom. In many cases, interactive multimedia is only used as a presentation tool by teachers, such as to display information or material without actively involving students. This keeps learning teacher-centered, even though the CTL philosophy is supposed to place students at the center of the learning process (Mustafa & Fatma, 2013). In addition, one of the main principles of CTL is to make learning relevant to students' daily lives. However, often the multimedia materials used are too generic and do not fit the context or personal experience of the student. As a result, interactive multimedia does not strengthen the relationship between the subject matter and the real life of students.

Discussion

Based on the results of the systematic literature review that has been carried out, it is found that interactive multimedia with the Contextual Teaching and Learning (CTL) approach has great potential in improving mathematics learning at the elementary school (SD) level. Most of the studies included in this review reported improved learning outcomes, motivation, engagement, and understanding of students' mathematical concepts when using interactive multimedia with the CTL approach compared to conventional learning methods. (Abdulrahaman et al., 2020; Geni et al., 2020; Kusumawati et al., 2021; Manurung & Panggabean, 2020).

These findings are in line with the theory of multimedia learning. (Mayer & Moreno, 2002) Which states that the use of a combination of text, images, animations, and sounds in learning can improve information understanding and retention in students. The CTL approach that relates learning materials to students' real-world contexts is also believed to increase student motivation and engagement in learning and has a significant positive effect on learning and cognitive load management. (Noetel et al., 2022)When students see the relevance between the mathematical concepts they learn and their daily experiences, they tend to be more interested and enthusiastic about participating in learning.

However, some researchers also revealed challenges in implementing interactive multimedia with the CTL approach Lack of funding for equipment and applications, as well as the lack of knowledge of most teachers, is a challenge in implementing interactive multimedia in schools. (Zhang et al., 2023). Not all schools, especially in rural or remote areas, have sufficient access to the computers, tablets, or internet needed to run interactive multimedia. Another challenge is the competence of teachers in integrating technology and the CTL approach to learning. (Maqoqa, 2023). Teachers need adequate training and support to be able to design and use interactive multimedia with the CTL approach effectively.

However, this review also reveals several strategies that can be implemented to overcome these challenges. One of them is by involving collaboration between teachers, material experts, and media developers in the process of developing interactive multimedia. (Beuchel et al., 2022). This collaboration can ensure that the multimedia developed is in accordance with the learning needs and context of students. Another strategy is to provide training and mentoring for teachers on an ongoing basis so that they can integrate interactive multimedia with the CTL approach in daily learning practices (Amin et al., 2020; Yildiz & Erdem, 2018).

This review also finds some key characteristics of interactive multimedia with a CTL approach that is effective in improving mathematics learning in elementary school. These characteristics include the use of visuals that are rich and relevant to the student's real-world context, interactivity that allows for active exploration, authentic presentation of problems, constructive feedback, scaffolding that suits the student's needs, and the integration of elements of art and aesthetics. (Abdulrahaman et al., 2020; Algers et al., 2013; Benning & Davis, 2023; Buchori, 2019; Geni et al., 2020; Liu, 2023; Peng et al., 2022; Radu et al., 2023; Sung, 2017; Tapingkae et al., 2020). These findings provide valuable guidance for multimedia developers and teachers in designing interactive multimedia with an effective CTL approach.

However, it should be acknowledged that there are still limitations in this review. First, the number of included studies is still limited (n=19) and most of them are from Asian countries. More research from different geographical and cultural contexts is needed to strengthen the generalization of the findings. Second, most studies use experimental or quasi-experimental designs with relatively short durations. A longitudinal study is needed to determine the long-term effects of the use of interactive multimedia with the CTL approach on students' mathematics learning. Third, this review only focuses on mathematics learning at the elementary level. Further research is needed to explore the effectiveness of interactive multimedia with the CTL approach in other subjects and different levels of education.

Conclusions

Overall, this SLR research has successfully identified that interactive multimedia with the CTL approach has great potential to improve mathematics learning at the elementary school level. Characteristics of interactive multimedia with an effective CTL approach include the use of rich and relevant visuals to real-world contexts, interactivity that allows active exploration, authentic presentation of problems, constructive feedback, scaffolding that suits the needs of students, and the integration of elements of art and aesthetics. This finding has important implications for mathematics learning practices in elementary schools. Multimedia teachers and developers can use these characteristics as a guide in designing interactive multimedia with an effective CTL approach. This study implies that teachers and researchers need to realize that the design and use of interactive multimedia with the CTL approach can effectively improve the quality of mathematics learning in elementary school. Indeed, the application of interactive multimedia with the CTL approach faces several challenges, such as the limitations of technology and the competence of teachers in using these tools. However, this challenge can be seen as an opportunity to make improvements in the future. Future research should also conduct longitudinal research to determine the long-term effects of the use of interactive multimedia with the CTL approach on student learning.

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Setyowati, R. R., Rochmat, S., Prof., Department of Social Sciences, Universitas Negeri Yogyakarta, Indonesia, saefur_rochmat@uny.ac.id, Aman, A., Prof., Department of Social Sciences, Universitas Negeri Yogyakarta, Indonesia, aman@uny.ac.id, Nugroho, A. N. P., & Lecturer, Department of Social Sciences, Universitas Negeri Yogyakarta, Indonesia, alifinur.pn@uny.ac.id. (2023). Virtual Reality on Contextual Learning during Covid-19 to Improve Students' Learning Outcomes and Participation. *International Journal of Instruction*, *16*(1), 173–190. https://doi.org/10.29333/iji.2023.16110a

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