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Trends in SAMR research in teaching and learning from 2019 to 2024: A systematic review

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ABSTRACT

This study reviews research on the use of the SAMR model (Substitution, Augmentation, Modification, and Redefinition) in teaching and learning from 2019 to 2024. A systematic review was carried out by searching the Scopus database. Based on specific selection criteria, 11 journal articles were chosen for analysis. The review identified five main areas discussed in these studies: levels of technology use in teaching, problems and challenges in using technology, effects on student learning, differences in how SAMR is applied in different places, and how SAMR can support meaningful learning. The results show that many teachers are still using technology at the basic levels (substitution and augmentation) because of limited resources, lack of training, and weak support from their institutions. This review suggests that more teacher training and better support are needed to help teachers move to higher levels of technology use (modification and redefinition). The study also gives ideas for future research and practice in the field of educational technology.

1. Introduction

Post The COVID-19 pandemic has accelerated the integration of technology in education. This has an impact on learning strategies that have changed, the most striking of which is the use of online learning platforms such as Zoom, Google Meet, Google Classroom, Teams, and Learning Management System (LMS) (Mahendra, 2021). The online learning platform for most educators makes it easier for students to access educational content from anywhere and anytime. Zoom, Teams, and Google Meet have been widely used to provide online meetings in learning, seminars, and workshops (Qiao et al., 2024). LMS and Google Classroom are routinely used in learning regularly and effectively for asynchronous learning and collecting student assignments (Muslem et al., 2024). The use of these platforms not only improves accessibility but also promotes inclusivity by ensuring equal access to technology and the Internet, especially for marginalized communities (Zhang and Wasie, 2023). These platforms have been widely used and integrated with highly innovative, interactive, and fun tools, such as game-based tools, artificial intelligence (AI), and augmented reality (AR). These tools allow educators to tailor instruction to individual student needs and create meaningful learning experiences, improving learning outcomes and preparing students with future-ready skills such as digital literacy, collaboration, and communication (Ratten, 2023).

Faceless learning, exercises, and assignments are very effective using LMS and other digital platforms (Muslem et al., 2024). Online platforms are generally used in cities and villages (Zhang and Wasie, 2023). The integration of platforms to become more interactive and innovative is with the addition of AI, AR, and VR. Teachers must be ready for technological advances, and students must become more independent and prepared to face the future

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(Ratten, 2023). The SAMR model, where substitution means the understanding of educators and students in the use of digital tools, has replaced the position of paper and pen (Cichoń et al., 2024; Tlili et al., 2023). Augmentation is a stage where educators feel comfortable using digital tools so that there is an increase in a more interactive direction (Muslimin et al., 2023a). Modification is defined as a more advanced stage of use by involving students in the use of technology (Bicalho et al., 2023; Buledi et al., 2024). Redefinition is the most advanced way for educators to integrate with digital technology, which has not existed before.

A systematic review of the SAMR model has many benefits, where the results of the analysis can be used as reference material to produce the latest research and make policies. Touchscreens are noted for their intuitive and interactive features, which have generated interest among young children. However, research findings regarding their effectiveness in enhancing learning outcomes are inconsistent. Tlili et al. (2023) also conducted systematic reviews of the changing landscape of mobile learning pedagogy. They explore the evolving role of mobile learning (ML) in education, particularly focusing on its pedagogical aspects. Despite the significant rise in mobile technology adoption, many studies emphasize technological aspects over pedagogical considerations. This literature review aims to bridge that gap by analyzing 165 empirical studies on mobile learning pedagogy. Based on some of the previous systematic reviews, it is necessary to know the trends of SAMR research in teaching and learning 2019-2024, which currently focuses on major global changes (e.g., remote learning hybrid education models). The rapid shift towards an online learning environment requires a closer look at how SAMR has been implemented, adapted, and evolved during that time. The review aims to analyze how SAMR has been used in teaching and learning, what trends have emerged, and what gaps still exist in its application. We identify vital studies, summarize their findings, and offer insights into future research and practice.

2. Method

This study used a systematic review and was adapted to the systematic review steps by Dixon-Wood (2006). A systematic review demands comprehensive, impartial, and replicable searches across various sources. It identifies as many relevant studies as possible (within available resources) to reduce bias and produce more accurate estimates of effects and uncertainties (Zawacki-Richter et al., 2020; Higgins and Green, 2008). The database used to answer a research question about SAMR is Scopus Database. Because the Scopus database is the biggest database in the world, the articles related to SAMR will be more comprehensive. We can see in Fig. 1 that the first step is defining the question. The question is, "How do we use the SAMR Model in teaching and learning? The second step is searching for the documents in the Scopus database related to SAMR using the term "SAMR." We found 107 documents.

The third step is designing the inclusion and exclusion criteria in Table 1. The fourth step is selecting the documents using the exclusion and inclusion criteria in Table 1. The selected articles found are 11 articles in Table 2.

3. Results and discussion

The fifth or final stage of the systematic review is to answer the questions. The answers to the questions from the selected articles can be seen in Table 3, which investigates several points, such as Technology Integration and SAMR Levels, Challenges and Barriers, Impact on Student Outcomes, Variability Across Contexts, and Potential for Transformative Learning.

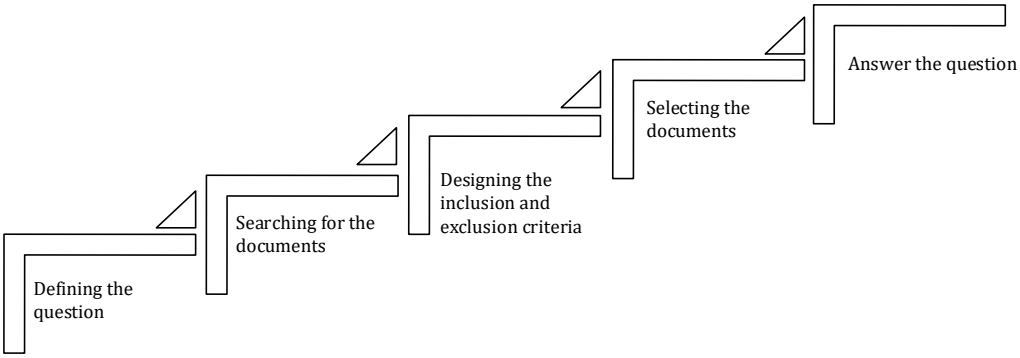

Fig. 1: Steps of systematic review by Dixon-Wood (2006)

Table 1: The inclusion and exclusion criteria

No.	Inclusion criteria	Exclusion criteria
1	The document should be a journal article	Systematic review
2	Implemented in the education field	
3	Implemented in teaching and learning	
4	The year of publication should be between 2019-2024	
5	The publication should be published with the complete volume and issue	
6	Published in English	

Table 2: The selected articles

No.	Journal	Reference
1	Contemporary Educational Technology	Boonmoh and Kulavichian (2023)
2	Computer-Assisted Language Learning Electronic Journal	Muslimin et al. (2023a)
3	Teaching English with Technology	Djiwandono (2023)
4	Contemporary Educational Technology	Muslimin et al. (2023b)
5	Art Education	McComb et al. (2022)
6	Educational Technology Research and Development	Bicalho et al. (2023)
7	LLT Journal	Alfiana et al. (2022)
8	Education and Information Technologies	Drugova et al. (2021)
9	International Journal of Early Childhood Special Education	Radhi and Sabri (2021)
10	International Journal of Information and Communication Technology Education	Tunjera and Chigona (2020)
11	Computer-Assisted Language Learning Electronic Journal	Howlett et al. (2019)

Table 3: The results from the selected articles

No.	Reference	Summary of SAMR Use in teaching and learning
1	Boonmoh and Kulavichian (2023)	Pre-service teachers mostly use technology at the substitution and augmentation levels. Factors limiting deeper integration include limited resources, time, and experience. More training is needed despite their digital background
2	Muslimin et al. (2023a)	This study used the TPACK-SAMR framework to assess digital skills of six Indonesian English lecturers. Although they had high digital competence, their classroom use was limited to augmentation. Results were consistent across public and private universities, but higher skills were found in wealthier cities
3	Djiwandono (2023)	Learners adopt more digital strategies as they move through SAMR levels. The study highlights the value of the SAMR model in supporting vocabulary learning and aligning with Bloom's taxonomy
4	Muslimin et al. (2023b)	This study found that lecturers' digital literacy and technostress levels varied. Lecturers in private universities had lower digital literacy and technostress, while those in rich cities had higher literacy and lower stress. Reducing technostress may support digital skill development
5	McComb et al. (2022)	Art educators in Michigan improved their teaching during the pandemic by discussing the SAMR model. They moved from simple substitution to full transformation. The model helped build community, guide discussions, and inspire teaching change
6	Bicalho et al. (2023)	Teachers integrated technology mainly at augmentation and modification levels. Substitution-level use had less impact. Successful integration depended on social, cultural, and institutional contexts
7	Alfiana et al. (2022)	The SAMR model helped improve students' critical thinking and learning outcomes. It also boosted students' confidence and encouraged more active learning
8	Drugova et al. (2021)	The study combined TPACK and SAMR to assess digital teaching innovations. Some teachers feared losing traditional roles. Students appreciated the technology's flexibility but faced technical problems
9	Radhi and Sabri (2021)	Using the SAMR model improved students' teaching behaviors and encouraged participation. The impact was strong on teaching skills overall, but limited for planning skills
10	Tunjera and Chigona (2020)	Teacher educators mostly used basic technology tools (e.g., PowerPoint, YouTube) at the substitution and augmentation levels. Limited professional development and digital confidence restricted deeper integration
11	Howlett et al. (2019)	The study highlights the value of combining technology training with service-learning for pre-service teachers. This approach helps them better support diverse students, especially English learners, through improved confidence and teaching effectiveness

3.1. Technology integration and SAMR levels

Many studies have shown that educators primarily operate at the substitution and augmentation levels of the SAMR model (e.g., Boonmoh and Kulavichian (2023), Muslimin et al. (2023a), and Drugova et al. (2021)). This is largely due to resource constraints, familiarity with technology, or institutional barriers. Balmes (2022) explored how technology can bridge traditional teaching methods and noted that despite technology's transformative potential, teachers often have trouble adapting and supporting, like Lim and Khine's (2006) findings. McKnight et al. (2016) emphasized that the success of technology in education lies not only in its availability but also in how effectively it is integrated into pedagogical practices. Similarly, Li and Ni (2012) discussed the challenges that EFL teachers in China face when integrating technology into their classrooms, mainly due to the need for comprehensive training and infrastructure support. This level primarily enhances existing tasks without significant transformation.

Substitution is a fundamental part of learning that does not involve much additional technology integration. Thus, in this substitution phase, educators do not experience many obstacles in using technology because they are already familiar with its application in learning. However, there have also been many studies whose findings show that educators are at the augmentation stage, where technically, there has been no significant transformation process. However, educators have increased the use of the benefits of technology in their learning so that learning becomes more meaningful. Learners can interactively use technology with teachers, increasing contribution and communication in learning.

In a study by Nguyen (2024), tertiary EFL teachers in Vietnam worked at the Substitution and Augmentation level, using essential tools such as PowerPoint, indicating the need for more profound pedagogical innovation. Likewise, research conducted by Orak and Alagözlü (2023) on ELT lecturers during emergency distance education revealed that most digital technology integration occurred at the Substitution level, with some evidence of Redefinition, which suppresses the time-intensive nature of the deeper SAMR levels. Meanwhile, Bicalho et al. (2023) found that Brazilian teachers' use of ICT during the pandemic was more closely aligned with Augmentation and Modification

levels, indicating progress in technology adaptation but highlighting barriers to full integration.

The SAMR model is a framework for integrating technology into the learning process. The Modification and Redefinition stage represents a higher level of technological integration, where there is a significant change in the learning process. In the Modification stage, technology is used to redesign parts of the assignment and change student learning. This stage is more than just an upgrade and begins to change the way tasks are performed. The research results of Ayu et al. (2023) showed that the level of Modification significantly affects students' creativity, especially in terms of flexibility in their projects. In EFL (English as a Foreign Language) teaching, the use of AI tools at the Modification stage has been shown to significantly improve students' writing achievement and learning perception (Tay et al., 2020) and in mathematics education, technology at the Modification stage can engage students more deeply, encouraging better understanding and participation.

The Redefinition stage involves using technology to create new tasks that were previously unimaginable. This stage transforms the learning experience by allowing activities that are fundamentally different from traditional methods. The results of Tay's et al. (2020) research showed that AI-powered tools at the Redefinition stage can reshape language learning, making it more effective and adapted to various educational settings. In mobile learning, the Redefinition stage is often used to leverage the unique capabilities of mobile technology, improving experiences and pedagogical outcomes (Jiang et al., 2024). Redefinition in mathematics education can lead to the creation of entirely new learning activities that engage students in innovative ways (Muslimin et al., 2023a). The results of the creativity level test showed the superiority of mathematics teachers in the experimental group who participated in the model-based training program (SAMR) compared to the teachers in the control group who did not participate in the training program. This may be because technology has changed the way of thinking in various ways, technology cannot be a tool to curb creativity, on the contrary, technology is a tool that stimulates creativity. Creativity serves to observe and interpret the world to achieve new ideas and concepts, while technology serves to see that world from a different perspective and access the necessary information anytime and anywhere. Because the training program contains activities, exercises, and several interactive sites related to mathematics, which is a fertile field for the development of thinking and challenges for the mind in situations and events faced by individuals, and daily training and model-based activity planning (SAMR) and various activities that use these skills, teaching methods and training media, as well as various training strategies, has a clear impact in meeting several training needs of trainees and achieving goals because training sessions have a positive impact and have proven to have an impact in increasing the level of creativity of mathematics teachers.

3.2. Challenges and barriers

Several studies (e.g., Tunjera and Chigona (2020) and Bicalho et al. (2023)) discussed the obstacles preventing educators from reaching higher SAMR levels (Modification and Redefinition). The very limited level of modification in SAMR learning processes is due to significant changes in the design of learning tasks by integrating technology. One of the activities at the modification stage is conducting science experiments, where students can use virtual laboratory simulation software. The modification level provides opportunities for fundamental changes in the learning process, independence, and freedom of students; this changes the atmosphere or learning strategy. The redefinition stage is the most limited in the SAMR model, based on the results of this systematic review, because the role of technology allows the production of new tasks that have never been done before. The redefinition stage in the learning process includes AR, VR, or documentary videos shared via YouTube or other social media. This can stimulate students to do projects.

Several research results also show that professional development for educators is significantly lacking in increasing the use of ICT in the learning process. Professional development is very important to improve teachers' beliefs and attitudes towards technology and how ICT is used in their teaching practices. Research by Bicalho et al. (2023), which applies Information and Communication Technology (ICT) in learning practices based on the SAMR model, especially during the COVID-19 pandemic, is seen from the perspective of teacher experience. Some teachers feel they can access technology; inadequate training and professional development support often hampers deeper integration of technology into learning practices. In addition, the results of Tunjera and Chigona's (2020) study highlighted the importance of professional development in using technology. This study shows that although educators have adopted technology daily, they often hesitate to apply it in their teaching due to inadequate training. This study also emphasizes the need for technology skilling at the education policy level to ensure that pre-service teachers are ready to use technology in their teaching. In addition, Kafle (2023) stated that the need for more continuous and reflective professional development results in educators' less confidence in utilizing more sophisticated digital tools. Moreover, the problem of time constraints, which prevents teachers from integrating technology deeply into their pedagogy, leads to a lower impact of SAMR's transformative potential.

ICT that coexists with educators and students needs to be reflected by supervisors or the

government to determine the level of ICT utilization in their learning process with the SAMR model. The challenges identified from the research by Drugova et al. (2021) are the problem of technological barriers, such as technical problems related to the platform, such as mobile applications that do not function properly, as well as accessibility difficulties for students and limited technological knowledge of teachers. Although the platform has developed great potential to improve student skills, many teachers do not understand how to integrate technology into the learning process effectively. They often feel that this platform does not fully match the existing curriculum. Another challenge in integrating ICT in the SAMR model is inadequate institutional support, such as institutional resistance to the invasion of technology that has emerged from all universities, causing teachers to worry that technology will replace their role, the lack of consistent, systematic feedback, and assessment of learning outcomes by the Institution, even in some universities which makes it difficult for universities to enter the modification and redefinition stages. Slow implementation and weak institutional support hinder this transformation. These barriers point to more substantial institutional support, ongoing technical training, and more targeted technology adoption strategies to move teachers and students through higher levels of technology integration, as proposed by the SAMR model.

The use of the SAMR (Substitution, Augmentation, Modification, and Redefinition) model in education can vary greatly between developed and developing countries, depending on access to technology, teacher capacity, and education policies of each country (Wijaya et al., 2021; Bicalho et al., 2023). The United States, Finland, and Australia are examples of developed countries that utilize SAMR models at the Modification and Redefinition level (Prakash, 2022; Inga et al., 2021), given the availability of adequate resources to integrate technology in innovative learning. At the Substitution level: Schools use e-books to replace printed books and devices such as Chromebooks and iPads in the classroom to read materials or to replace notebooks. At the Augmentation level, teachers use learning applications such as Seesaw to assess student work with video and audio feedback or Quizizz for interactive evaluations in the classroom, as well as Google Classroom which allows digital assignment collection, real-time feedback, and virtual classroom management. At the modification level, students use technology-based science simulations such as PhET Simulations or Labster for virtual experiments that replace physical laboratories, and project-based learning with technology, such as making interactive documentaries using video editing applications (Alnaser and Forawi, 2024). At the advanced level, namely redefinition, there is student involvement in research-based learning with real-time data, for example using IoT devices to monitor the environment. In addition, it can also be done by conducting global collaboration projects, such as STEM learning with VR/AR through applications such as CoSpaces or participating in a global coding program (Hour of Code) (Hwang and Chien, 2022; Pellas et al., 2020).

In developing countries, such as Indonesia, India, and Nigeria, the implementation of SAMR models is often still concentrated in the early stages (Substitution and Augmentation) due to limited infrastructure and technological resources (Reardon et al., 2021; Gawer and Bonina, 2024). At the substitution level, for example, with the start of crowded use of E-learning such as Moodle or local platforms such as Ruangguru and YouTube replacing print modules (Rahmadı, 2021). At the augmentation level, Indonesia uses WhatsApp or Google Forms for student evaluation, because these applications are more accessible (Yusuf et al., 2024). At the modification level, for example in Indonesia implement applications such as Canva or Flipgrid to create creative presentations for students (Lionenko and Huzar, 2023). While in Nigeria, it is still limited, some schools use simple apps like Google Slides for project-based learning (Oguguo et al., 2023). The level of redefinition in India and Indonesia is still limited, but coding-based learning initiatives through Code.org for students in big cities are beginning to emerge and there are STEM learning initiatives with simple devices such as Arduino for science experiments (Sarah et al., 2024).

Developed countries such as the United States and Finland apply more Modification and Redefinition while developing countries such as Indonesia and India still focus on Substitution and Augmentation. However, global collaboration initiatives and wider access to technology provide opportunities to accelerate the adoption of SAMR models in developing countries.

3.3. Impact on student outcomes

Research on the influence of SAMR on student learning outcomes has been widely explored, especially on critical thinking and student engagement (Alfiana et al., 2022; Radhi and Sabri, 2021). The four levels of SAMR provide opportunities for students to think critically. Higher stages (Modification and Redefinition) encourage student collaboration and creativity, especially redefinition, which is the culmination of critical thinking, where students are involved in innovative and collaborative projects that integrate various media and resources. The SAMR model is also designed to increase student engagement in learning.

In this digital era, various skills will emerge and improve significantly through meaningful learning, such as social skills; collaborators, and communication (Sari et al., 2024). Student learning independence is highly demanded in this digital era which makes students have full responsibility in exploring the use of technology, analyzing information, and developing their scientific

arguments. High skills will clearly pass the positive impact of improving learning outcomes, as revealed by Lestari and Munir (2022), student learning outcomes increase with the use of technology that shifts from traditional. 21st-century skills such as critical thinking (Aprinaldi et al., 2018) and scientific awareness (Ibrahim and Mohammed, 2024) have increased with the existence of SAMR.

3.4. Variability across contexts and potential for transformative learning

The level of SAMR implementation is influenced by variability in various contexts such as institutional carrying capacity, field of study, and geography (Muslimin et al., 2023a; Drugova et al., 2021). The carrying capacity of the institution will increase the stages of modification and redefinition (McComb et al., 2022) so that the field of study used will be more flexible and flexible with satisfactory final achievements (Crompton and Burke, 2020). Suwarna and Zulfiani (2024) developed Web Virtual Inquiry (WIV) as a learning medium that is integrated with Inquiry Learning, which can improve students' digital literacy and questioning skills. During the implementation, students felt more involved in learning, and the teaching materials presented were more interactive and interesting. These tasks are designed with varying levels of difficulty so that they can be adjusted to the student's ability and level of understanding.

Pomeranz (2024) analyzed the use of Minecraft Education Edition for students in elementary schools to understand the concept of renewable energy. This activity is at the Modification and Redefinition Level, where students are assigned to design a virtual city with environmentally friendly energy sources, such as solar panels and wind turbines. They work collaboratively to plan the layout of the city, calculate energy consumption, and test the sustainability of their design through simulations in Minecraft. These activities have an impact on improving critical thinking skills, collaboration, and creativity. In addition, the activity also combines various subjects, such as mathematics (energy calculation), geography (urban design), and science (renewable energy). The results of the study show that students better understand the importance of renewable energy and can solve real-world problems with innovative approaches.

Kallakurchi and Banerji (2020) analyzed STEM learning in a secondary school in Bangalore, India. Students use robotics devices such as Lego Mindstorms to learn coding and problem-solving in STEM contexts. This activity is at the Modification Level, where students learn programming logic and algorithms through this project. The impact found is that this learning helps students understand the connection between technology, math, and science. In addition, it also improves 21st century skills, such as problem-solving, and systemic thinking skills, and students are more confident in facing technological challenges. Geographical location also greatly affects the use of technology and has an impact on the framework of SAMR stages. So according to Sastria (2023), the use of technology in densely populated geographical areas and being used to using technology will improve their learning experience.

4. Conclusion

The conclusions that can be drawn from the systematic review of SAMR research trends in teaching and learning 2019-2024 are SAMR's focus on Technology Integration and SAMR levels, challenges and obstacles, impact on student outcomes, variability across contexts, and transformative learning potential. Professional development is a very urgent need today, seeing that most of the research is only in the substitution and augmentation stages (Muslimin et al., 2023b). Support from various parties is also needed so that learning increases at the modification and redefinition stage (Tunjera and Chigona, 2020). Further research is better if using the meta-analysis method to quantitatively examine the trend of articles related to the SAMR model both in developed and developing countries.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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