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Information Communication Technology (ICT) based Science Learning to Increase Student Creativity

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Abstract This research is a systematic review research with 32 limited articles from 2015 to 2023. This study aims to answer research questions about what teaching materials are used in learning, improving what aspects of 21st century skills and learning models are used in teaching materials. This research is systematic review literature. The method used in this research is Systematic Literature Review (SLR) using the Preferred Reporting Items for Systematic Reviews and Metaanalyses model. The study's conclusions are consistent with its goals for research: First, the best electronic teaching resources are employed to accomplish learning goals are E-books or e-modules, Websites, Storytelling, Games, PPT, Virtual Reality, Argumended Reality, Edmodo and Animation. Second, electronic teaching materials improve aspects of 21st century skills, namely creativity skills, science literacy, critical thinking, concept understanding, collaboration and communication with the learning model, namely blended learning, PjBL, PBL and Inquiry. It is hoped that this research can be an illustration for other researchers to create electronic teaching materials for innovative learning.

Keywords Learning science, ICT, 21st century skills.

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INTRODUCTION

Information communication and technology (ICT) is increasingly developing to make teaching and learning methods carried out, designed and implemented according to the wishes and needs of students (Arif Fatahillah et. al., 2021). Information Technology (Information Technology) or the term information communication and technology (ICT) or better known as ICT is a technology that is needed to manage, process, and convey information regardless of place and time. ICT is also characterized as a form of facilitation that allows the flow of information to be very easy to obtain (Abdul Manaf et al., 2015). Communication technology and information is also very influential on the world of education to create creativity, interest, motivation in learning (Obonyo, C., et. al., 2018).

1 ICT stands for information, communication, and technology. Mobile devices like computers, laptops, cell phones, audio players, and electronic books are used in electronic learning and education. One of them has an impact in the teaching materials used such as PPT, pictures, e-books, e-modules, e-LKPD, animated videos and others. With the aid of the internet and technical advancements, ICT enables students to study cooperatively with one another and exchange ideas without regard to time or location constraints. (Isa Jahnke a, Julia Liebscher 2019). The application of ICT in science learning can help educators to further minimize the use of learning media that is applied especially in the delivery of learning materials that require a better process. Science is a branch of science whose focus of study is nature and the processes that exist in it (Aria R, 2021).

Learning made possible by technology can aid in removing obstacles between the classroom and real life. It's quite appealing for introducing students to new places, eras, and geographies in the classroom (Ying-Tze Chen, et al., 2023). Some academics claim that technology-enabled learning can serve as a link between formal and informal learning, allowing one to compare and contrast the two depending on features and context. The majority of the literature discusses how affordable it is to use teacher-centered mobile learning techniques, strategies, and applications. There are basic problems with the theoretical and pedagogical underpinnings for the application of mobile learning in education that are currently insufficient and off target, in addition to the actual implementation concerns that arise in learning practices. Numerous writers examine and analyze this from a socio-constructivist perspective, and they conclude that mobile devices' communication capabilities can foster teamwork and serve as the cornerstone of mobile learning. Instead of using the resources or media, students might engage in active learning with one another and themselves. Therefore, for technology-based learning to be effective, all facets of education—government, educators, students, and society at large must adapt. (Shao, M., Liu, X. (2021).

4 Some research suggests that mobile devices can have a positive impact on learning in general, but it is not always clear how educators use mobile technology or how they design learning to enhance student creativity (Naylor, Gibbs, 2018).

In the 21st century, there are several skills that students must have, known as the 4Cs (Critical Thinking, Communication, Collaboration, Creativity and Innovation). It is important to develop students' higher-order thinking competencies, such as creative thinking and critical

thinking skills (Jahnke et, al., 2017). Technology-based education can be a creative option (M. Shao, X. Liu, 2021). In addition to assisting teachers and students in understanding the subject matter being studied, technology learning helps pupils develop their higher-order thinking, communication, and problem-solving abilities. Students with higher order thinking skills are able to think at a higher level. Pupils with this aptitude will assess, analyze, and come up with novel solutions to issues.

Based on this, appropriate pedagogical methods and theories are needed to assist teachers in designing learning using technology to enhance students' creativity and critical thinking (Liping Sun, et al., 2016). This method has strategies to integrate technology learning into the classroom to achieve learning objectives with technology aids. In addition, the strategy should embed problem-based learning skills to enhance students' creativity and critical thinking (Desak Made Anggraeni, et al., 2023). This review was produced using systematic content analysis of empirical science education research articles. The review above, which was produced through a methodical content analysis of empirical research articles on science education, aims to address the following queries:

- What electronic teaching materials are used in learning?
- What 21st century skills can be improved when utilizing ICT in science learning, especially using these electronic teaching materials!

METHOD

This research is a systematic literature review. The method used in this study is Systematic Literature Review (SLR) using the Preferred Reporting Items for Systematic Reviews and Metaanalyses model or called PRISMA. This method researchers do by identifying, reviewing, evaluating and interpreting all available research. With this method, the researcher reviews and identifies journals systematically in each process following predetermined steps. By encouraging evidence-based activities, conducting more objective evaluations of previous efforts, and identifying new research directions, the SLR approach advances our understanding of research topics (Sun, L., et, al., 2023). To ensure systematic SLR, this study followed the PRISMA guidelines.

Electronic scientific databases such as Sinta, Scopus, and ScienceDirect (Elsevier) were searched to find pertinent studies. These databases were chosen due to their interdisciplinary scope, usability, and theme relevance. The electronic scientific database literature search was conducted using the PRISMA framework.

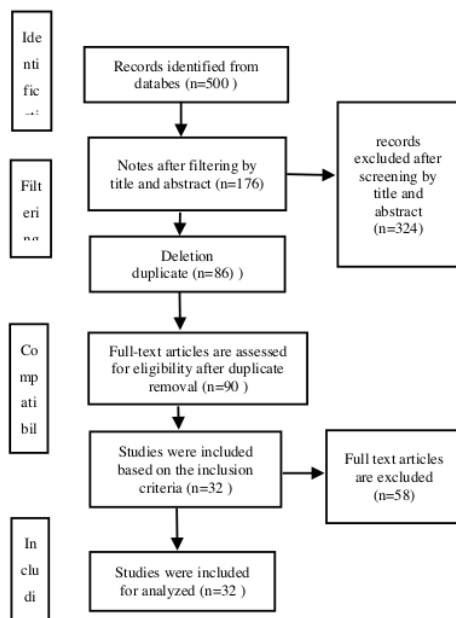
Table 1. Publishers of analysis articles

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Electronic scientific databases such as Sinta, Scopus, and ScienceDirect (Elsevier) were searched to find pertinent studies. These databases were chosen because of their theme-

relevant content, accessibility, and multidisciplinary coverage. The PRISMA framework was utilized to conduct a literature search within an electronic scientific database.

This study used secondary data for its data collection. The documentation method from existing data is applied to secondary data, instead of data obtained from direct observation. The procedure is divided into four stages: (1) As illustrated in Figure 1, the steps are identification, (2) screening, (3) eligibility, and (4) inclusion. The initial step entailed performing a methodical search of electronic databases, as illustrated in Figure 1. Studies that satisfied the following inclusion requirements were chosen: (a) The study is an empirical investigation into learning that makes use of ICT to enhance 21st century skills through teaching and learning. (b) Junior secondary school education is the study's educational level. (c) The study was released between 2015 and 2023. (d) English is used in the research paper. A visual representation of the PRISMA criteria is provided below.



After this search, 500 results were found. The titles and abstracts of chosen studies were then screened in the second stage. 176 pertinent papers were produced overall by this screening process; however, upon reviewing the screening results, it was discovered that 86 of them were duplicates. In the third step, 90 full-text articles were chosen, and their eligibility was evaluated. During this procedure, each paper was carefully read, and only those that met the following inclusion requirements were chosen for inclusion: The study incorporated pertinent data on ICT (as mentioned above), learning models (b) and research methods (c). 32 scientific articles that satisfied the selection criteria were taken into consideration for the final extraction after this process. At the last phase, the caliber of the scientific publications (n=32) was assessed based on the research questions.

RESULT AND DISCUSSION

Teaching materials that should be used in learning are flexible and easy to understand. Electronic teaching materials are of course teaching materials that require a smartphone or computer as a place for these teaching materials (W. H. Wu, C. Y. Chen, H., et, al., 2012). The results of the study reported that in learning, e-books or e-modules are the most frequently used electronic teaching materials according to Table 2.

Table 2. Electronic teaching material analysis results

Electronic Teaching Materials	F	P
E-book atau E-modul	9	28,12%
Website	4	12,5%
Phet	1	3,12%
Geogebra	1	3,12%
Storytelling	3	9,37%
Game mobile	3	9,37%
Virtual Reality (VR)	1	3,12%
Power Point (PPT)	1	3,12%
Edmodo	2	6,25%
Argumented Reality (AR)	3	9,37%
Animation	1	3,12%
Application	3	9,37 %

The results of the analysis of ICT utilization in learning the highest electronic teaching materials, namely E-modules 28.12% E-modules based on ethnoscience guided inquiry (Kirana, C., 2023), Problem Based Learning (PBL) based E-modules (Imaningtyas, C. D., et, al., 2016), Flip PDF Professional-based digital book (Febrianti, F. A., 2021), interactive E-book (Agustin, L., et, al., 2019), basic physics practicum guide E-module (Defianti, A., (Suzuki, S. N., et, al., 2020), E-module of general chemistry platform for first year students (Schettini, C., et, al, 2020), E-module based on Project Based Learning (PjBL) Integration with CCR Implementation in Science Education (Ulfa, E. M., et, al., 2023), E-Book based on Socio Scientific Issues (SSI) (Asi, M., et, al., 2021).

E-modules are ICT utilization of electronic teaching materials that are widely used in learning in schools because in addition to saving the use of paper e-modules are more efficient and practically easy to make and use by students and teachers, E-modules are also

teaching materials that can help students measure and control their learning abilities and intensity. The use of modules is not limited by place and time, because it depends on the ability of students to use the module. Thus, the developed e-modules can be used anytime and anywhere using smartphones that most students already have in this technological era (Laili, L., 2019).

There are 87% of studies that aim to measure the improvement of student learning that report that they successfully achieve the set goals. In a review of previous research, of all subjects, natural science is the subject that uses electronic teaching materials used (M. Liu, R. Scordino, et al., 2014).

The use of ICT in learning has a positive impact, namely improving creativity skills, critical thinking, communication, collaboration, science literacy, concept understanding and understanding processes. Based on the analysis of creativity skills is the highest aspect of the use of electronic teaching materials according to table 3.

Table 3. Results of Analysis of Improvement Aspects

Aspek Peningkatan	F	P
Creativity	9	28,12%
Critical thinking	7	21,87%
Process Skills	3	9,37%
Science literacy	3	9,37%
Colaboration	1	3,12%
Communication	1	3,12%

The results of the analysis increase the highest creativity, namely 28.12% E-learning in the form of a website increases creativity and concept assignment (Yuda, I. G. N. H., et, al., 2015), E-modules based on guided inquiry increase students' creative thinking ((Kirana, C., 2023), ICT-based learning assisted by geogebra software increases creativity and understanding of student concepts (Wardaya, P., et, al., 2015), Blog and Facebook-based learning on student creativity (Rianawaty, I., 2015), Storytelling discovering scientific increases student creativity (Chen, Y. T., et, al., 2023), 2015), Blog and Facebook-based learning on student creativity (Rianawaty, I., 2015), Storytelling discovering scientific increases student creativity (Chen, Y. T., et, al., 2023), Mobile games increase student creativity (Atwood-Blaine, D., et, al., 2019), Mobile learning increases student creativity (Chang, Y. S., et, al., 2016), Mobile games increase student creativity (Stolaki, A., Economides, A. A., 2018). There are several articles that only make electronic teaching materials but do not measure student improvement only student responses.

M. M. Terras and J. Ramsay suggested that electronic teaching materials in learning can expand teacher pedagogy and develop students' 21st century skills. In this analysis, several learning models are used in electornic teaching materials, namely, blanded learning,

inquiry, Project Based Learning (PjBL), Problem Based Learning (PBL). There are some using the Socio Scientific Issues (SSI), Ethnoscience approach. There are several studies that do not use models and approaches in electronic teaching materials.

Using electronic teaching materials in learning can help students gradually develop their statistical thinking in daily life. Students have the concept of self-learning with their characters so that interaction occurs continuously (Burden and M. Kearney, 2016). Currently, mobile devices enter the classroom because mobile learning has a more significant effect than learning that does not use mobile devices, of course it is utilized, especially in learning in the form of teaching materials used (Adilah Afikah, et al., 2022).

Learning models to improve 21st century skills, Project Based Learning (PjBL) is one of the science learning models that are widely used in electronic teaching materials (M. Shao and X. Liu, 2021).

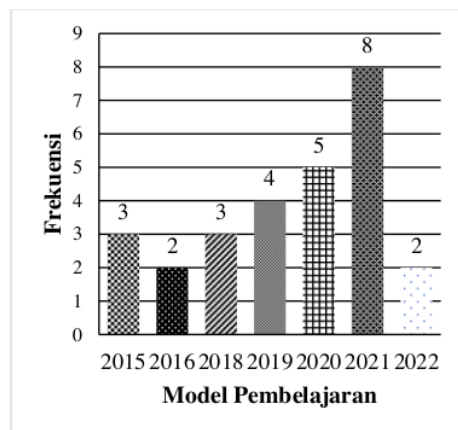


Figure 1. Diagram of Learning Model

Project-based learning, often known as PjBL, is the science learning methodology that is used in electronic teaching materials (M. Shao and X. Liu, 2021). Through project-based learning, students examine and resolve challenging issues (R. D. Anazifa and Djukri, 2017). Students are better able to research, investigate, and ask questions when they use inquiry-based learning. Problem-Based Learning (PBL): According to M. Shao and X. Liu (2021), problem-based learning is the science learning approach used in electronic teaching materials. A learning technique known as "problem-based learning" centers on a particular occurrence or issue in order to help students improve their problem-solving and self-control abilities. The next blended learning science learning model applied in electronic teaching materials is blended learning. It combines face-to-face learning with technology-mediated learning (Idris, H., 2018).

The highest percentage of learning models used to improve 21st century skills, namely creativity skills, is Project Based Learning (PjBL). There are some articles that do not use learning models but use approaches in their electronic teaching materials.

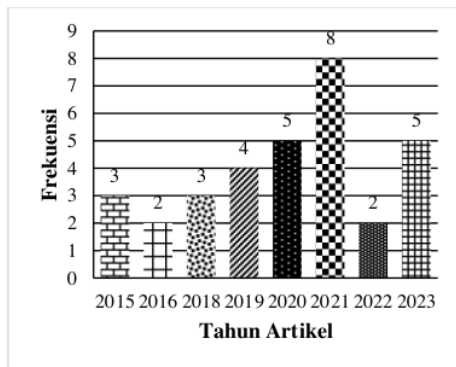


Figure 2. Year of Article

The articles analyzed range from 2015-2023, many articles, namely in 2021 as many as 8 articles, then 2020 as many as 5 articles, in 2023 5 articles, 2020 5 articles, 2019 4 articles, 2018 3 articles, 2015 3 articles, 2022 2 articles and 2016 2 articles. In 2021, the most articles were caused because during the co-19 pandemic, teaching was carried out online, this made the use of technology in learning in the form of electronic teaching materials, this also had a positive impact until now on the use of electronic teaching materials to improve student skills in the 21st century.

This study has several limitations to its findings: Firstly, this study examined the use of ICT in what electronic teaching materials are most frequently used in science learning. Secondly, and most importantly, various factors other than electronic teaching materials, 21st century skills enhancement and learning models.

CONCLUSION

This study offers an up-to-date overview of electronic teaching materials tools for science learning, which can strengthen the foundation of scientific research and be helpful to future researchers. When it comes to achieving learning objectives, electronic books, websites, games, narrative, PowerPoint, augmented reality (AR), virtual reality (VR), animation, Edmodo, and gaming are the most ideal electronic teaching resources. It is also hoped that this study would serve as an example for future scholars in developing better 21st century skills. By using cutting-edge learning models, electronic teaching materials can also enhance 21st century skills like creativity. Project Based Learning (PjBL), Blended Learning, Problem Based Learning (PBL), Inquiry, and Discover are some of the innovative learning models used in science education to enhance 21st century skills. Ethnoscience and Socio Scientific Issues (SSI) are two methods. Furthermore, the availability of electronic teaching resources has created an environment in which a variety of learning objectives, including autonomous learning, learning at any time and from any location, learning based on interests, and learning to identify the traits of individual students, can be met.

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