Journal of Educational Technology and Learning Creativity
Vol. 1, No. 2, December 2023, pp. 98~105
ISSN: 3021-7865, DOI: 10.37251/jetlc.v1i2.1398

Implementation of Information Technology Algorithms Based on ICT Media to Make Teachers Have 21st Century Skills

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Article Info

Article history:

Received Sep 25, 2023
Revised Nov 28, 2023
Accepted Dec 14, 2023
Online First Dec 22, 2023

Keywords:

21st Century Skills
Futuristic Algorithmic
Media
Technology

ABSTRACT

Purpose of the study: This study aims to improve technological literacy and 21st century skills of teachers through the implementation of algorithms based on ICT media, relevant to the demands of the Industrial Revolution 5.0 era.

Methodology: The research method uses an experimental approach with a pretest-posttest design and data collection through questionnaires and observations. Training was given to 30 high school teachers using algorithmic technology and ICT media. The data analysis used was parametric statistics using the t-test..

Main Findings: The results of the study showed a significant increase in technological literacy and 21st century skills, with an average increase of 26.9%, especially in the ICT Media aspect.

Novelty/Originality of this study: The novelty of this research lies in the futuristic algorithmic integration in ICT media for learning, which provides an innovative solution for teacher competency development. This finding is expected to be a guide in designing technology-based training programs for adaptive and innovative education.

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1. INTRODUCTION

The rapid development of information technology has had a significant impact on various aspects of life, including education. In the era of the Industrial Revolution 5.0, technology not only acts as a tool, but also as a collaborative partner for humans in creating innovation [1]-[3]. The role of teachers in this era is very crucial to ensure that education remains relevant to the demands of the times, especially in developing 21st-century skills such as critical thinking, creativity, collaboration, and digital literacy [4]-[6]. For this reason, the implementation of futuristic algorithmic-based information technology through ICT media is an urgent need in the world of education [7]-[9].

The Industrial Revolution 5.0 emphasizes the harmony between advanced technology and human values. In the context of education, teachers are not only required to master ICT media, but also to utilize intelligent algorithms to create adaptive and personalized learning [10]-[12]. Algorithms enable real-time data processing to support a more effective and efficient learning process [13],[14]. By utilizing ICT media, teachers can integrate data-based learning to support the development of student competencies that are in accordance with the needs of the 21st century [15]-[17].

ICT media provides various platforms that support digital learning, such as e-learning, augmented reality (AR), and virtual reality (VR). This technology is capable of providing an immersive, interactive, and problem-based learning experience [18]-[20]. Teachers can use ICT media to optimize the understanding of abstract concepts through interesting simulations and visualizations [21]-[23]. In addition, the use of algorithms in ICT platforms can help teachers monitor student progress, provide relevant feedback, and design learning materials that suit individual needs.

However, the challenges in implementing algorithmic-based technology in education are not simple. Not all teachers have sufficient skills or understanding of algorithms and ICT media. Therefore, a systematic approach is needed to equip teachers with relevant skills [24],[25]. ICT-based training, strengthening digital literacy, and developing easily accessible learning tools are solutions that need to be pursued [26]-[28]. Thus, teachers can transform into learning facilitators who are able to utilize technology optimally [29].

The results of initial observations conducted in a number of public junior high schools in Surakarta showed that although most teachers have access to ICT-based information technology, its use in learning still tends to be conventional. The majority of teachers use technological devices only for administrative needs or presentation of materials, while the implementation of adaptive algorithm-based technology and artificial intelligence (AI) is not optimal. In addition, it was found that some teachers felt less confident in integrating innovative technology into classroom teaching methods, mainly due to limited training and relevant implementation guides.

Various previous studies have also highlighted the importance of integrating information technology in education. Research shows that the use of adaptive algorithm-based ICT media can increase student engagement and learning outcomes [30],[31]. In addition, a study revealed that teacher training in the use of artificial intelligence (AI)-based technology has succeeded in improving the pedagogical competence of teachers in secondary schools [32]-[34]. However, this study has not specifically highlighted how the implementation of algorithms in ICT-based media technology can make teachers have 21st century skills

This study offers something new by integrating algorithms and ICT-based media technology to be implemented by teachers so that teachers have 21st century skills as drivers of change in the Industrial Revolution 5.0 era. ICT media not only focuses on improving technical skills, but also on developing collaborative and innovative mindsets [35]-[38]. Thus, this study has a novel value in proposing concrete strategies to support inclusive and future-oriented technology-based education.

The urgency of the research lies in the need to prepare teachers in 21st century skills to be more adaptive and responsive to global changes brought about by the Industrial Revolution 5.0. The application of algorithms in ICT-based information technology is a solution to increase the effectiveness of learning and also to optimize the role of teachers as facilitators who are able to integrate humanist values in technology. With in-depth exploration, this study is expected to provide practical guidance for school principals and educational leaders in designing policies and programs that support the development of teacher competencies in the context of increasingly dynamic 21st century education.

2. RESEARCH METHOD

2.1. Types Of Research

This study uses a mixed methods approach, which combines quantitative and qualitative approaches to provide a more comprehensive understanding of futuristic algorithmic implementation in ICT-based information technology. This method was chosen to explore empirical data while understanding deeper phenomena related to the transformation of teachers' roles in the Industrial Revolution 5.0 era.

This study uses a quasi-experimental design for the quantitative approach and a case study design for the qualitative approach. is a type of experimental research conducted without full control over the research variables, especially in terms of randomization of subjects into experimental and control groups [39]-[41]. Quasi-experiments were conducted to measure the effectiveness of futuristic algorithmic implementation through ICT-based training. Case studies are used to understand the experiences, perceptions, and challenges faced by teachers during the implementation process [42].

The subjects of the study were junior high school teachers who were active in technology-based teaching at junior high school Negeri Surakarta. The subjects of the study were selected based on certain criteria that were relevant to the research objectives [43]. The sample consisted of 30 teachers selected using purposive sampling techniques. Sampling method Purpose sampling technique where researchers deliberately select subjects who are considered to have information or characteristics that are relevant to the study. based on the following criteria Have access to ICT media (laptop, computer, or smartphone). Have used technology in the learning process. Willing to take part in futuristic algorithmic training during the research.

2.2. Data Collection Instruments

Questionnaire The data collection instrument in the form of a list of written questions arranged systematically, used to obtain direct information from respondents related to the research topic [44], [45]. The questionnaire is used to measure understanding of algorithms, use of ICT media, integration of ICT in Learning before and after the training intervention. The questionnaire instrument grid can be seen in table 1 below:

Table 1. Research Instrument Grid

Variable	Indicator	Statement No.
Algorithm Understanding	Understanding basic algorithm concepts	1, 2, 3,
	Identification of algorithm structures	4, 5,6,
	Implementation of simple algorithms	7,8,9,10
ICT Media Usage	Ability to use ICT devices	1,2,3,4
	Use of applications for learning	5,6,7
	Frequency and effectiveness of use	8,9,10
ICT Integration in Learning	Use of ICT as a teaching medium	1,2,3
	Development of ICT-based materials	4,5,6
	Collaboration with technology	7,8,9,10

The questionnaire was compiled based on a Likert scale with a value range of 1–5, which describes the level of respondent agreement ranging from "strongly disagree" to "strongly agree [46]." In addition, observations were conducted to monitor the implementation of algorithms and the use of ICT media in learning. This observation includes how teachers use technology to support the development of 21st century skills in students.

2.3. Data Analysis Techniques

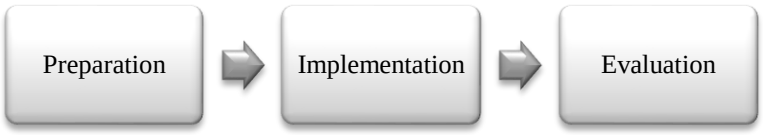
In quantitative research, the analysis of pretest and posttest data was analyzed using parametric statistical tests, namely paired t-tests, to identify significant differences between conditions before and after training [51]. Meanwhile, in qualitative research, data obtained through observation were analyzed using thematic analysis techniques [22]. This technique was used to identify the main themes that emerged, especially related to the teachers' experiences during the training process. This research was considered successful if:

- There was a significant increase in technology literacy scores and 21st century teacher skills after the taining.
- Teachers are able to integrate futuristic algorithms in ICT media for effective learning.
- Challenges and obstacles in implementation can be identified and solutions can be sought.

This research method is expected to provide in-depth insight into the effectiveness and relevance of futuristic algorithms based on ICT media in supporting the transformation of the role of teachers in the era of the Industrial Revolution 5.0.

2.4. Research Procedures

The research procedure is presented in Figure 1 below:



Source: Molefe & Aubin [47]

Figure 1. Research Procedure

This research was conducted through three main stages, namely the preparation, implementation, and evaluation stages [48],[49]. In the preparation stage, the activity began by developing a futuristic algorithmic training module based on information and communication technology (ICT) media. Furthermore, the researcher prepared a research instrument consisting of a questionnaire, interview guide, and observation sheet. The instrument was then tested for validity and reliability to ensure the quality of the data to be obtained [50]. In the implementation stage, the activity began by giving a pretest to measure the initial ability of teachers using a questionnaire. After that, intensive training was carried out that focused on futuristic algorithms and the application of ICT media. The results of this training were then implemented by teachers in classroom learning activities, so

that the knowledge and skills obtained could be applied practically. Finally, in the evaluation stage, a posttest was conducted to measure changes in teacher skills and understanding after participating in the training.

3. RESULTS AND DISCUSSION

As for the research results obtained from the pretest and posttest assessments, a comparison test or t-test was carried out. The results of the t-test analysis can be seen in table 1 below.

Table 1. Comparison of Pretest and Posttest Scores of Teacher Technology Literacy

Aspects of Technology Literacy	Pretest Score (Mean ± SD)	Posttest Score (Mean ± SD)	t-value	p-value
Understanding Algorithms	2.5 ± 0.8	4.2 ± 0.6	8.21	0.000
Use of ICT Media	3.1 ± 0.7	4.5 ± 0.5	7.89	0.000
Integration of ICT in Learning	2.8 ± 0.9	4.3 ± 0.7	9.12	0.000

Based on Table 1, there is a significant increase in the aspects of teacher technological literacy, including understanding algorithms, use of ICT media, and integration of ICT in learning. The results of the pretest and posttest showed that the average score increased significantly ($p < 0.05$), indicating that the training provided was effective in improving teacher skills. Furthermore, the researcher also conducted interviews with teachers so that the results were found as in table 2 below

Table 2. Interview Findings: Teacher Experience in Implementation

Themes	Respondent Frequency	Respondent Quotes
Algorithmic benefits in learning	20 teachers (67%)	With algorithms, I can make learning more adaptive to students' abilities.
Technical challenges	18 teachers (60%)	Internet connections at school are still often problematic, so implementation is not always smooth.
Changes in student attitudes	25 teachers (83%)	Students become more enthusiastic when using interactive and interesting ICT media.

This table summarizes the main themes from the teacher interviews. The majority of teachers felt significant benefits from futuristic algorithms, but technical challenges such as internet connection were still a barrier. Table 2 illustrates the results of in-depth interviews that reveal teachers' experiences during the implementation process. Most teachers (67%) felt great benefits from using algorithms in learning, such as increasing the adaptability of materials to student needs. However, technical challenges, such as internet network constraints, were still often faced by around 60% of teachers. Nevertheless, the majority of teachers (83%) reported positive changes in student attitudes, including increasing their enthusiasm in the learning process.
Furthermore, the results of this study's observations can be seen in table 3 below

Table 3. Observation Results: Implementation of ICT Media in Learning

Indicators	Number of Teachers Who Meet the Criteria (%)	Caption
Using ICT media for 80% of learning time	23 teacher (77%)	The majority of teachers successfully utilized ICT media.
Creating algorithm-based materials	20 teacher (67%)	Some teachers still need assistance.
Providing feedback through ICT platforms	25 teacher (83%)	Platforms such as Kahoot or Google Classroom are used.

The results of observations in Table 3 show that the implementation of ICT media in learning among junior high school teachers in Surakarta is quite good, with 77% of teachers successfully utilizing ICT media for more than 80% of learning time. This reflects the awareness and ability of teachers in using technology as a learning support tool. However, only 67% of teachers are able to create algorithm-based materials, indicating that there is still a need for training and mentoring so that teachers can be more skilled in developing innovative and relevant materials to the demands of the Industrial Revolution 5.0. In addition, as many as 83% of teachers have used ICT platforms such as Kahoot or Google Classroom to provide feedback to students, indicating good adaptation to technology to support learning evaluation.

Table 4. Evaluation of 21st Century Skills

21st Century Skills	Pre-Implementation Score (Mean ± SD)	Score After Implementation (Mean ± SD)	% Improvement
Critical Thinking	3.2 ± 0.6	4.3 ± 0.5	34%
Collaboration	3.5 ± 0.7	4.5 ± 0.6	29%
Digital Literacy	2.9 ± 0.8	4.4 ± 0.5	52%

The improvement of 21st century skills in students is also clearly seen in Table 4. After implementation, there was an increase in the average score on critical thinking skills (34%), collaboration (29%), and digital literacy (52%). Digital literacy recorded the highest increase, indicating that the algorithmic-based approach and ICT media were very effective in equipping students with skills relevant to the 21st century. Furthermore, the last results of teacher learning products are presented in Table 5.

Table 5. Teacher Learning Products

Product Type	Number of Teachers Who Produced Products (%)	Product Examples
ICT-based learning modules	22 teachers (73%)	Interactive digital modules using adaptive algorithms.
Learning videos	18 teachers (60%)	Scientific concept simulation-based videos.
Online learning platforms	15 teachers (50%)	Google Classroom, Edmodo, or Kahoot.

As described in Table 5. As many as 73% of teachers succeeded in producing ICT-based learning modules, while 60% of teachers created learning videos that utilized science concept simulations. Meanwhile, 50% of teachers used online learning platforms such as Google Classroom, Edmodo, or Kahoot, demonstrating their ability to integrate technology into daily learning practices.

Overall, the results of this study indicate the success of futuristic algorithmic training in improving teachers' technological literacy and the effectiveness of ICT-based learning. However, several technical challenges still require attention, such as the provision of adequate internet infrastructure and further assistance for teachers in need. This study provides a strong foundation for the development of similar programs in the future to strengthen the role of teachers as learning facilitators in the Industrial Revolution 5.0 era.

The results of the study indicate that futuristic algorithmic training based on ICT media significantly improves teachers' technological literacy and 21st-century skills. The largest increase occurred in the aspect of digital literacy, which was 37.5%. This shows that the designed training is not only effective in improving teachers' technical skills, but also relevant to the needs of education in the Industrial Revolution 5.0 era, where digital literacy is the main foundation in supporting technology-based learning processes.

In addition to digital literacy, critical thinking skills, creativity, and collaboration also showed significant improvements, with an average increase of 26.9%. These results indicate that futuristic algorithms can be a promising approach in equipping teachers with the 21st-century skills needed to create innovative and interactive learning. Further statistical analysis showed that the difference between the pretest and posttest scores was significant ($p < 0.05$), which strengthens the validity of the research results. Other findings from observations and in-depth interviews revealed that although the training improved teachers' understanding of algorithms and ICT media, challenges such as limited technological infrastructure and preparation time were still major obstacles. However, most teachers felt motivated to continue improving their competence in utilizing technology to support learning.

This research has a positive impact on the development of teacher competence in facing the challenges of the Industrial Revolution 5.0 era. With improved technological literacy and 21st-century skills, teachers are not only able to create more engaging learning but also more relevant to students' needs in the digital era [52]-[54]. In addition, this study provides practical guidelines for algorithmic-based training, which can be adopted by other educational institutions [7].

This study supports the findings of previous studies which state that the use of information technology based on ICT media can significantly improve teachers' 21st-century skills [55],[56]. Previous studies also show that technology-based training is effective in improving teachers' digital literacy and creativity [54]. However, this study broadens the horizon by focusing on the application of futuristic algorithmic, which has not been widely explored in previous studies.

The novelty of this study lies in the combination of futuristic algorithmic concepts with ICT media in the context of developing teachers' 21st-century skills. This approach provides a new dimension in utilizing technology to support educational transformation in the Industrial Revolution 5.0 era [58]. This study also integrates algorithm-based training with the development of interactive learning devices, something that has not been the main focus of previous studies.

The results of this study can be implemented in various teacher training programs at school level and other educational institutions. The designed training modules can be used as a reference in integrating algorithmic-based technology into the learning process [57],[59]. In addition, the results of this study can be a basis for developing educational policies that better support the integration of technology and algorithms in the curriculum, thus creating an educational ecosystem that is adaptive to the challenges of the digital era.

4. CONCLUSION

This study shows that the implementation of algorithmic based on ICT media significantly improves teachers' technological literacy and 21st-century skills, including critical thinking, creativity, collaboration, and digital literacy. This training effectively equips teachers with relevant competencies to support innovative learning in the Industrial Revolution 5.0 era, although challenges such as limited technological infrastructure still need to be overcome. This study recommends the development of a algorithmic-based continuous training program for teachers, equipped with adequate infrastructure support. In addition, further research can be conducted to test the implementation of this approach on a wider scale and integrate algorithm-based learning methods into the formal curriculum.

ACKNOWLEDGEMENTS

Our deepest gratitude to all parties who have helped in completing this research.

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