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Action Research: Optimizing Students' 4C Skills through Gamification-Based Interactive Digital Media

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Abstract

This study aims to optimize university students' mastery of 21st-century competencies—critical thinking, communication, collaboration, and creativity (4C)—through the implementation of gamification-based interactive digital media in the learning process. Employing classroom action research with the Kemmis and McTaggart spiral model, the study was conducted in two cycles involving 27 students from the Early Childhood Education Study Program. Data were collected through structured observation to objectively monitor the implementation and outcomes of the intervention, and analyzed both descriptively and quantitatively by comparing results across cycles. The findings indicate a significant improvement in students' 4C skills, as evidenced by an increase in average scores from 62.38 in cycle 1 to 81.77 in cycle 2, and a rise in completion rates from 26.63% to 88.89%. These results demonstrate the effectiveness of gamification-based interactive digital media in enhancing students' 4C competencies. The study concludes that this approach not only strengthens essential 21st-century skills but also contributes to pedagogical innovation through technology integration, offering a valuable reference for the development of active learning strategies in higher education.

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Keywords: 4C Skills; Gamification; Interactive Digital Media; Active Learning; Higher Education Innovation

INTRODUCTION

The development of digital technology in the era of the 4.0 industrial revolution has had a profound impact on various sectors of human life, one of which is higher education. This digital transformation has changed the pattern of interaction between teachers and students, from one that previously focused on the role of lecturers as the center of information to one that places students at the center of learning activities. This paradigm shift has created a demand for innovation in learning strategies, methods, and media in order to adapt to the characteristics of the digital generation, which is familiar with technology. In this context, higher education institutions are challenged to create a learning environment that not only imparts knowledge but also develops higher-order thinking skills. The competencies that are an important focus are 21st-century skills known as the 4Cs, which include critical thinking, communication, collaboration, and creativity (Darmuki et al., 2022; Anton & Trisoni, 2022; Sanjayanti & Pramadi, 2020; Selman & Jaedun, 2020; Triana et al., 2020). These four skills are seen as the foundation that students must master in order to face dynamic global challenges, adapt to ever-changing technological developments, and be able to compete in a world of work that demands flexibility and innovation.

Mastery of the 4C skills is in line with the objectives of higher education, which is not only to produce graduates who have mastered academic knowledge, but also have the capacity to communicate effectively, collaborate with others, and foster creativity and the ability to solve complex problems (Thornhill-Miller et al., 2023; Andrian & Rusman, 2019). In the digital economy era, students are required to combine hard skills such as technological literacy and data analysis with soft skills such as interpersonal communication, leadership, and critical thinking that is adaptive to change (Triana et al., 2020; Ekaputra et al., 2024). It is no surprise that educators in higher education need to adopt a more interactive, collaborative, and project-based learning approach so that students can develop their full potential (Yulianto et al., 2024; Rehman et al., 2024).

Strengthening 4C skills is not only important for academic success, but also equips students to contribute productively to an ever-changing global society (Tian & Zheng, 2025).

Students who possess 4C skills are believed to be able to deal with problems in various situations by thinking critically to find logical, creative, and innovative solutions. Research combining gamification with the flipped classroom and project-based learning models has shown a significant improvement in students' critical and creative abilities (Ekaputra et al., 2024). However, a study on skill transfer using a competitive gaming environment found that not all aspects of 4C were effectively transferred to real-world tasks (Zhong et al., 2025). The ability to collaborate effectively facilitates the completion of complex tasks, while good communication skills help reduce the risk of miscommunication within teams. Hone creativity, especially when supported by technology or a gamification approach, can foster innovative ideas in academia and the workplace (Ranuharja et al., 2024; Alonso-Sánchez et al., 2025). Mastering the 4C skills is not merely a supplement to the curriculum, but a key for students to face the dynamics of global challenges, optimize their potential, and play an active role in national development.

Based on the results of a survey conducted during the lecture period, students' 4C skills are still relatively low. This condition is evident when the learning process is dominated by lecturers transferring knowledge, while students tend to be passive. This situation results in students' creative ideas being less stimulated and less appreciated, so that their higher order thinking skills (HOTS) are not optimally honed. As a result, students are not accustomed to seeking various alternatives in problem solving. Furthermore, analysis of final exam answers shows that students have difficulty answering questions that are application-based and require problem-solving skills. Therefore, efforts are needed to improve the quality of learning through the use of more effective, interesting, and targeted media so that the course objectives can be optimally achieved. One solution that can be implemented is the use of interactive digital media based on gamification to encourage active student participation and develop their 4C skills.

Interactive digital media based on gamification is a learning approach that adapts game elements such as points, levels, badges, leaderboards, and challenges—into an educational context to increase student motivation, engagement, and active participation (Vosiqova & Khadjibayeva, 2024; Alshammari, 2023; Romero & Kalmpourtzis, 2020). Gamification is the application of techniques and strategies from a game to a non-game

context with the aim of solving a problem. Gamification here aims to increase student motivation, engagement, and participation in the learning process (Oliveira et al., 2023). The use of gamification in learning will increase learning motivation in both formal and informal settings (Yunita & Indrajit, 2022). Research shows that the application of gamification can facilitate the development of 21st-century skills, such as critical thinking, collaboration, communication, and creativity (4C), as well as improve student learning outcomes in higher education (Wanglang & Chatwattana, 2023; Samala et al., 2023; Sailer & Homner, 2020).

A number of gamification platforms have been proven effective in supporting interactive digital learning. For example, Wordwall can increase student engagement and literacy comprehension through interactive quizzes and diagram visualization (Wahid et al., 2025), as well as supporting participatory mathematics learning (Rezeki & Amelia, 2025). Quizizz also encourages healthy competition through game-based quizzes that can reduce test anxiety and improve academic performance (Fatima, 2025). Meanwhile, Kahoot! and Blooket help create fun and interactive quiz-based learning, and Gimkit facilitates collaboration through team-based games that motivate learning. Other studies confirm that leaderboard-based learning in STEM courses can significantly increase student engagement and learning outcomes (Ortiz-Rojas et al., 2025). Considering this, the use of gamification-based interactive digital media not only makes learning more interesting but also strengthens motivation, collaboration, and the development of students' higher-order thinking skills. Thus, the purpose of this study is to optimize students' mastery of 4C skills, which include critical thinking, communication, collaboration, and creativity, through the application of gamification-based interactive digital media in the learning process in higher education.

METHODS

This study applies a classroom action research approach that focuses on improving actual conditions in the classroom to be more effective in accordance with the expected learning objectives. Fahmi (2021) explains that action research is carried out through a series of planned actions to improve the methods, strategies, rules, and concepts used in a process so that they can produce better quality than before. This research is not only aimed at solving problems that arise in the classroom, but also at developing sustainable learning

practices that can have a positive impact on the overall engagement and learning outcomes of students.

This research design uses the Kemmis and McTaggart spiral model, which emphasizes a systematic cycle of repeated actions to improve learning effectiveness. In line with Arikunto et al. (2021) view, the more often the actions are applied, the more significant the improvement in learning outcomes is expected to be. In practice, each cycle consists of the planning stage, implementation of actions accompanied by observation, and reflection, which forms the basis for the preparation of improvement measures in the next cycle. This spiral model is considered appropriate because it provides room for adaptation to real problems in the field so that the actions taken are more relevant to learning needs.

The subjects of this study were 27 third-semester students in class R001 of the Early Childhood Education Study Program at the University of Jambi who were taking the Family Child Education course. The success indicator was determined based on learning outcomes, namely that the study would be terminated if at least 75% of students had obtained a final score of ≥75 in accordance with the predetermined target. Research data was obtained through observation techniques to monitor the implementation and achievement of actions objectively. Data analysis was conducted using a quantitative descriptive approach with descriptive statistics, while the success rate of each cycle was analyzed using a percentage formula to determine measurable improvements in results. This approach was chosen to provide a clear and systematic overview of the progress of each cycle of action taken.

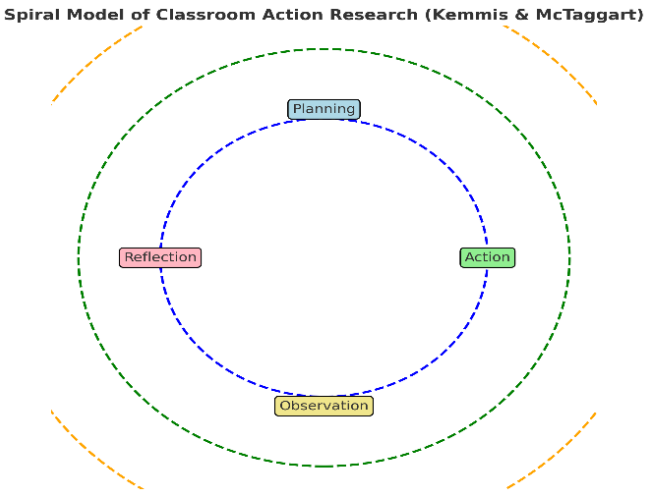


Figure 1. Research Flow

RESULTS

This study was conducted in two cycles with the aim of optimizing the learning process and improving students' 4C skills, namely critical thinking, creativity, collaboration, and communication, through the application of gamification-based interactive digital media. The implementation of the two cycles was designed to monitor progress gradually so that changes could be measured in a structured and continuous manner. Each cycle included the stages of planning, implementation, observation, and reflection, which formed the basis for developing improvement measures for the next cycle. The findings obtained are expected to demonstrate the real impact of the application of gamification-based interactive digital media on improving students' 4C skills in the Family Child Education course.

a. Cycle 1 Results

In the cycle 1 classroom action phase, data was collected and analyzed in percentage form using Microsoft Excel. The data obtained was related to the percentage scores of students' 4C skills in the Family Child Education course, with the application of gamification-based interactive digital media. The analysis results showed that the students' 4C skills in cycle 1 did not show an even increase. Of the total participants, 8 students (26.63%) were classified as proficient, while 19 students (73.37%) were still in the non-proficient category. This indicates that the use of gamification-based interactive digital media was not fully effective in improving students' 4C skills in the initial cycle.

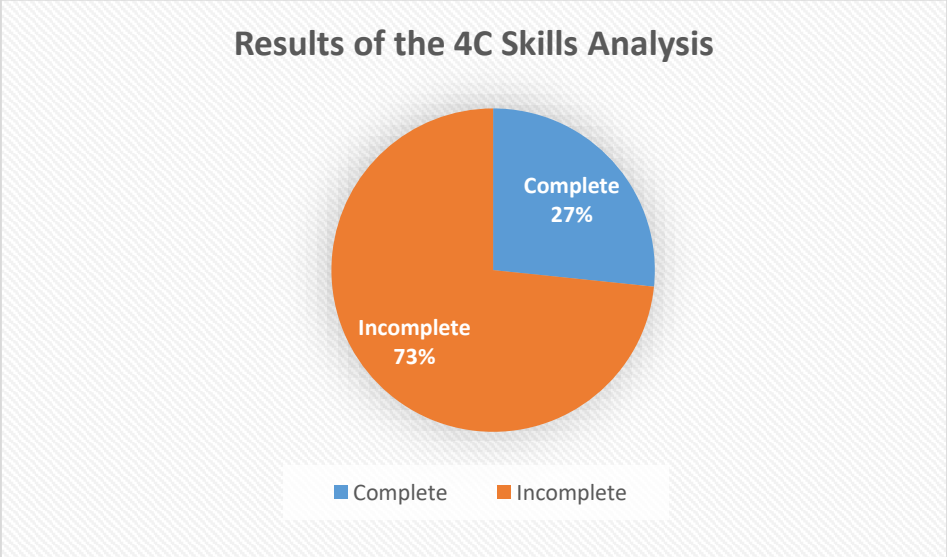


Figure 2. Results of the 4C Skills Analysis in Cycle 1

The results of the description of student 4C skills data, consisting of data for each indicator, are outlined in the table below:

1) *Critical Thinking*

Table 1. Critical Thinking Indicator Score Acquisition

No	Score Interval	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	2	7%
2.	10 < Score≤ 13	Good	5	19%
3.	7 < Score ≤ 10	Poor	20	74%
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on table 1 above, it can be seen that the critical thinking indicator scores of 27 students were as follows: 2 students obtained a very good category with a percentage of 7%, 5 students obtained a good category with a percentage of 19%, 20 students obtained a poor category with a percentage of 74%, and no students obtained a very poor category.

2) *Collaboration*

Table 2. Collaboration Indicator Score Acquisition

No	Score Interval	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	2	7%
2.	10 < Score ≤ 13	Good	7	26%
3.	7 < Score ≤ 10	Poor	18	67%
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on table 2 above, it can be seen that the collaboration indicator scores of 27 students were as follows: 2 students obtained a very good category with a percentage of 7%, 7 students obtained a good category with a percentage of 26%, 18 students obtained a poor category with a percentage of 67%, and no students obtained a very poor category.

3) *Communication*

Table 3. Communication Indicator Score Acquisition

No	Score Interval	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	4	14%
2.	10 < Score ≤ 13	Good	5	18%
3.	7 < Score ≤ 10	Poor	19	68%

No	Score Interval	Category	Frequency	Percentage
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on table 3 above, it can be seen that the communication indicator scores of 27 students were as follows: 4 students obtained a very good category with a percentage of 14%, 5 students obtained a good category with a percentage of 18%, 19 students obtained a poor category with a percentage of 68%, and no students obtained a very poor category.

4) *Creativity*

Table 4. Creativity Indicator Score Acquisition

No	Score Interval	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	3	11%
2.	10 < Score ≤ 13	Good	5	18%
3.	7 < Score ≤ 10	Poor	20	71%
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on table 4, the scores obtained on the creativity indicator from 27 students show that 3 students (11%) are classified as very good, 5 students (18%) are classified as good, and 20 students (71%) are in the poor category. No students obtained a very poor category. During the implementation of learning in cycle 1, no significant obstacles were found in the research process. However, the application of gamification-based interactive digital media is needed in cycle 2 to further improve students' 4C skills.

b. Cycle 2 Result

The results of the 4C skills analysis in cycle 2 show an increase in student abilities after the implementation of gamification-based interactive digital media. Of the total 27 students who were the subjects of the study, 24 students (88.89%) successfully achieved the mastery category, while 3 students (11.11%) remained in the non-mastery category. These findings indicate that the use of gamification-based interactive digital media contributes significantly to the improvement of students' 4C skills.

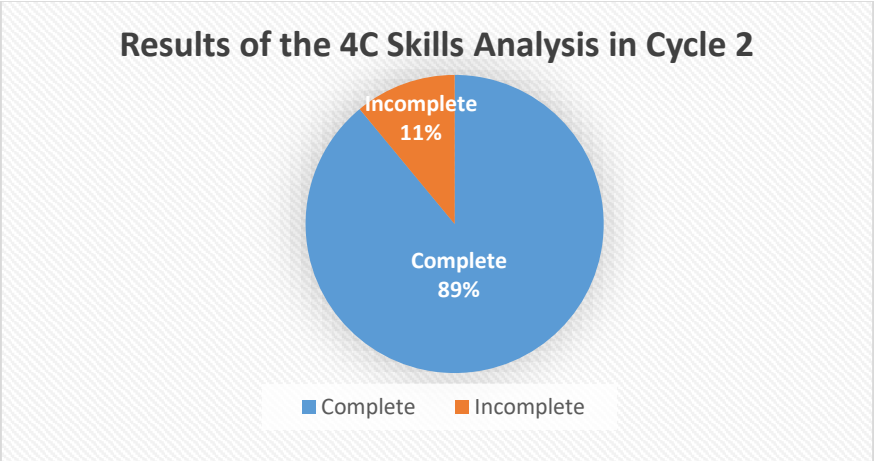


Figure 2. Results of the 4C Skills Analysis in Cycle 2

The results of the description of student 4C skills data, consisting of data for each indicator, are outlined in the table below:

1) *Critical Thinking*

Table 5. Critical Thinking Indicator Score Acquisition

No	Score Interval	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	10	37%
2.	10 < Score ≤ 13	Good	15	56%
3.	7 < Score ≤ 10	Poor	2	7%
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on table 5 above, it can be seen that the critical thinking indicator scores of 27 students were as follows: 10 students obtained a very good category with a percentage of 37%, 15 students obtained a good category with a percentage of 56%, 2 students obtained a poor category with a percentage of 7%, and no students obtained a very poor category.

2) *Collaboration*

Table 6. Collaboration Indicator Score Acquisition

No	Interval Score	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	9	33%
2.	10 < Score ≤ 13	Good	17	63%
3.	7 < Score ≤ 10	Poor	1	4%
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on table 6 above, it can be seen that the collaboration indicator scores of 27 students were as follows: 9 students obtained a very good category with a percentage of 33%, 17 students obtained a good category with a percentage of 63%, 1 student obtained a poor category with a percentage of 4%, and no students obtained a very poor category.

3) *Communication*

Table 7. Communication Indicator Score Acquisition

No	Score Interval	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	9	33%
2.	10 < Score ≤ 13	Good	18	67%
3.	7 < Score ≤ 10	Poor	0	0%
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on Table 7 above, it can be seen that the communication indicator scores of 27 students were as follows: 9 students obtained a very good category with a percentage of 33%, 18 students obtained a good category with a percentage of 67%, and no students obtained a poor or very poor category.

4) *Creativity*

Table 8. Creativity Indicator Score Acquisition

No	Score Interval	Category	Frequency	Percentage
1.	13 < Score ≤ 16	Very Good	11	41%
2.	10 < Score ≤ 13	Good	15	56%
3.	7 < Score ≤ 10	Poor	1	4%
4.	4 < Score ≤ 7	Very Poor	0	0%
	Total		27	100%

Based on table 8, the scores on the creativity indicator of 27 students show that 11 students (41%) are in the excellent category, 15 students (56%) are in the good category, and only 1 student (4%) is in the poor category, while no students are in the very poor category. The implementation of classroom activities carried out in two cycles—cycle 1 and cycle 2—showed an increase in students' 4C skills in the Family Child Education course through the application of gamification-based interactive digital media. This improvement was reflected in the average score, which rose from 62.38 to 81.77, as well as an increase in

the percentage of mastery from 26.63% in cycle 1 to 88.89% in cycle 2. Referring to the research success indicator, namely that at least 75% of students achieve a final score of ≥75, the action is declared successful, so the cycle is stopped at the second cycle. Details of the implementation results for each cycle are shown in the following table.

Table 9. Description of Cycle 1 and Cycle 2 Implementation Results

No	Cycle Results	Cycle 1	Cycle 2
1.	Highest Score	92.18	96.87
2.	Lowest Score	50	68.75
3.	Average	62.38	81.77
4.	Number of Students Completing the Course	8	24
5.	Completion Rate (%)	26.63	88.89%

DISCUSSION

The results of the study show that the application of gamification-based interactive digital media can significantly improve students' critical thinking, creativity, communication, and collaboration (4C) skills. This improvement can be seen from the increase in the average score and completion rate in cycle II compared to cycle I. This shows that the integration of game elements into the learning process encourages students to be more actively involved, think critically, and collaborate in completing tasks. This finding is in line with the study by Lampropoulos & Sidiropoulos (2024), which proves that properly designed gamification can improve student learning outcomes and academic performance in a sustainable manner. In addition, game elements such as points, badges, leaderboards, and challenge missions are external factors that motivate students to improve their learning performance (Khaldi et al., 2023).

The success of this digital media cannot be separated from the principle of multimedia learning, which combines text, visuals, audio, and interactive features to maximize the information processing process. Mayer & Fiorella (2021) explain that the appropriate use of multimedia can help reduce cognitive load and support the formation of better mental representations, thereby strengthening conceptual understanding and higher-order thinking skills. In addition, gamification designs that require students to undergo a process of exploration, reflection, and repetition of exercises are in line with the experiential learning framework (Kong, 2021; Radović et al., 2021). This approach provides students with the opportunity to learn through real experiences and direct problem solving,

which has been proven to be more effective in building critical and collaborative thinking skills than traditional lecture methods.

Improving 4C skills is also closely related to motivational aspects. Gamification with reward elements, quick feedback, and options for students to choose their learning path play an important role in fulfilling basic psychological needs such as autonomy, competence, and social connectedness as described in Self-Determination Theory (Wang et al., 2024). Fulfilling these three needs is key to fostering intrinsic motivation and higher learning engagement. Ruiz et al. (2024) add that increased engagement encourages students to be more active in group communication, take the initiative to express ideas, and work together to solve complex problems. These conditions support the strengthening of all 4C elements in an integrated and sustainable manner.

The results of this study confirm that the effectiveness of gamification media is not only determined by the presence of digital technology alone, but also by the suitability of the game design elements to the learning objectives. Khaldi et al., (2023) emphasize that elements such as leaderboards, tiered challenges, and strong game narratives can encourage more intensive social interaction, collaboration, and communication among participants. In the context of this study, students not only competed to achieve high scores, but were also trained to complete group tasks, discuss strategies, and provide constructive feedback on the work of their groupmates. These findings show that the appropriate integration of gamification can improve students' ability to collaborate, hone their creativity in problem solving and communicate effectively with other group members.

The findings of this study have important practical implications for the development of learning in higher education, particularly in courses that require the strengthening of 21st-century skills. Educators can use the principles of multimedia learning Mayer & Fiorella (2021), experiential learning Kong (2021), and SDT motivational theory Wang et al. (2024) as a basis for designing gamification media to improve 4C skills. From a theoretical perspective, this study adds empirical evidence on the effectiveness of digital gamification in supporting the development of critical, creative, collaborative, and communicative thinking skills, which have been the focus of 21st-century education. However, this study still has limitations in the form of a relatively small number of participants and a context limited to one specific course. Therefore, further studies with a broader population, involving a variety of courses and institutions, as well as adding

longitudinal analysis are needed to ensure the sustainability and generalization of the findings.

CONCLUSION

The results of the study show that the application of gamification-based interactive digital media can improve students' 4C skills, which include critical thinking, communication, collaboration, and creativity. This improvement can be seen from the increase in the average student score from 62.38 in cycle I to 81.77 in cycle II, as well as an increase in the completion rate from 26.63% to 88.89%. These findings confirm that the integration of gamification elements such as tiered challenges, quick feedback, and team collaboration in digital media can encourage active student engagement, strengthen learning motivation, and significantly support the development of 21st-century skills.

Although showing positive results, this study has limitations in the form of a relatively small number of participants, a research context limited to one course, and a short implementation period, so it cannot yet describe the long-term impact of digital gamification on 4C skills. To strengthen these findings, future research should involve a larger number of participants, a more diverse range of courses, and a longitudinal design to evaluate the sustainability of the impact of digital gamification. Further exploration of gamification element designs such as adaptive narratives, project-based challenges, and data-based feedback is also needed to optimize the effectiveness of interactive digital media for developing students' 4C skills in higher education.

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