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THE HYBRID GAMIFICATION-TPACK (TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE) APPROACH IN IMPROVING 4CS SKILLS AND PHYSICAL LITERACY OF JUNIOR HIGH SCHOOL STUDENTS IN ATHLETIC LEARNING

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Abstract

This study aims to analyze the effect of the Hybrid Gamification-TPACK approach on improving 4Cs Skills (Communication, Collaboration, Critical Thinking, Creativity) and Physical Literacy of 8th-grade students in athletic learning. Methods: This study used a quasi-experimental design with a pretest-posttest control group design. The research population was all 8th-grade students of SMPN 1 Cikao, Garut Regency, totaling 48 students who were sampled using total sampling technique. The sample was divided into experimental group (n=24) receiving Hybrid Gamification-TPACK learning and control group (n=24) receiving conventional learning. The intervention duration was 10 weeks with a frequency of 2 meetings per week. Research instruments used 4Cs Skills Assessment Rubric and Physical Literacy Assessment for Youth (PLAY) Tools. Data analysis used Independent Sample t-test and Paired Sample t-test with significance level α=0.05. Results: Results showed significant improvements in the experimental group for 4Cs Skills (pretest: M=64.25, SD=8.67; posttest: M=85.17, SD=6.42; $p<0.001$) and Physical Literacy (pretest: M=68.50, SD=9.23; posttest: M=87.33, SD=7.15; $p<0.001$). The control group also experienced improvements but not as significant as the experimental group. There were significant differences between experimental and control groups on posttest 4Cs Skills ($p<0.001$; Cohen's d=2.89) and Physical Literacy ($p<0.001$; Cohen's d=2.42). Conclusion: The Hybrid Gamification-TPACK approach proved effective in improving 4Cs Skills and Physical Literacy of junior high school students in athletic learning and can be an innovative alternative in 21st-century Physical Education learning

Keywords: Gamification, TPACK, 4Cs Skills, Physical Literacy, Athletics, 21st Century Learning

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INTRODUCTION

Physical education in the 21st century faces new challenges in preparing students for the complexities of life and an increasingly dynamic world of work. Learning should not only focus on developing motor skills, but also integrate essential 21st-century skills for future success (Robles & Estevez, 2023). The Partnership for 21st Century Learning emphasizes the importance of mastering the 4Cs Skills Communication, Collaboration, Critical Thinking, and Creativity as fundamental competencies that must be developed in the context of contemporary education (Saavedra & Opfer, 2012).

In the context of Physical Education, the 4Cs Skills are highly relevant because learning takes place through social interaction, tactical problem solving, team communication, and creativity in game strategies. Physical Literacy is defined as "the motivation, confidence, physical competence, knowledge, and understanding to appreciate and take responsibility for lifelong engagement in physical activity" (Whitehead, 2013). This concept goes beyond motor skills alone and encompasses holistic cognitive, affective, and behavioral dimensions. Research shows that Physical Literacy is positively correlated with long-term participation in physical activity, mental health, and individual quality of life. individuals (Cairney et al., 2019). However, data shows that Indonesian students' Physical Literacy levels are still low, especially in terms of motivation and sustained engagement in physical activity (Hartati et al., 2021).

Athletics education in junior high schools often faces problems in maintaining student motivation and engagement. Athletics subjects such as running, jumping, and throwing tend to be considered monotonous and uninteresting for digital generation students who are accustomed to technological stimulation (Casey et al., 2021). Conventional drill-based approaches often fail to develop students' cognitive and affective aspects and are unable to facilitate the optimal development of 4Cs Skills (Baena-Extremera et al., 2016). This condition requires learning innovations that can integrate technology, effective pedagogy, and meaningful learning content. Gamification in education is defined as "the use of game elements and mechanics in a non-game context to increase learner motivation and engagement" (Deterding et al., 2011). Recent research shows that gamification effectively increases intrinsic motivation, active participation, and learning outcomes in Physical Education (Ferreira et al., 2023). Gamification elements such as points, badges, leaderboards, quests, and challenges have been proven to create a more engaging and enjoyable learning experience (Kapp, 2012). However, effective gamification implementation requires a strong pedagogical understanding so that it is not merely entertainment without learning substance.

Technological Pedagogical Content Knowledge (TPACK) is a framework that integrates three domains of teacher knowledge: Content Knowledge (CK), Pedagogical

Knowledge (PK), and Technological Knowledge (TK) (Mishra & Koehler, 2006). This framework emphasizes that effective integration of technology in learning requires an understanding of how technology, pedagogy, and content interact to create meaningful learning (Koehler et al., 2013). In the context of Physical Education, TPACK helps teachers design learning that not only utilizes technology as a tool, but also integrates it pedagogically to enhance understanding of athletic content. students (Jang & Chen, 2010). The Hybrid Gamification-TPACK approach combines the power of gamification in increasing motivation with the TPACK framework in designing pedagogical technology integration. This approach has not been widely explored in Physical Education research, especially in athletics material at the junior high school level. The research by (Fernández-Vázquez et al., 2024). Found that gamification can improve students' motor skills, but it has not comprehensively explored its impact on 4Cs Skills and Physical Literacy. Meanwhile, research on TPACK in Physical Education has focused more on teachers' perceptions and competencies (Kim et al., 2013). rather than on student learning outcomes.

Based on this research gap, this study aims to analyze the effect of the Hybrid Gamification-TPACK approach on improving the 4Cs Skills and Physical Literacy of eighth-grade students in athletics learning. This study is expected to contribute theoretically to the development of 21st-century Physical Education learning innovations and provide practical implications for teachers in designing more effective, engaging, and meaningful learning.

METHOD

This instrument Research Design This study used a quantitative approach with a quasi-experimental pretest-posttest control group design. This design was chosen because it was not possible to fully randomize the research subjects, who were already divided into specific classes (Creswell & Creswell, 2018). The study was conducted over 10 weeks with a frequency of two meetings per week, each meeting lasting 80 minutes in accordance with the allocation of time for physical education at school.

Population and Sample The study population consisted of all 48 eighth-grade students at SMPN 1 Cikao, Garut Regency, for the 2024/2025 academic year. The sampling technique used total sampling, where the entire population was used as the research sample. The sample was divided into two groups: the experimental group (Class VIII-A, n=24) which received learning using the Hybrid Gamification-TPACK approach, and the control group (Class VIII-B, n=24) which received conventional learning based on demonstrations and drills. The groups were divided based on existing classes, taking into account the equality of initial characteristics through pretest results. Sample inclusion

criteria: (1) eighth-grade students actively enrolled at SMPN 1 Cikao, (2) no injuries or physical conditions that would hinder participation in athletic learning, (3) willingness to participate in the entire research series, and (4) attendance of at least 80% of the total meetings. Of the 48 initial students, all met the criteria and completed the research program until the end.

Research Instruments 1. 4Cs Skills Assessment Rubric. This instrument is adapted from the Critical Thinking and Communication Skills Assessment Rubric developed by Greenstein (2012) and has been modified for the context of Physical Education. The rubric measures four dimensions of the 4Cs: a. Communication Skills (25 points): The ability to convey ideas verbally and non-verbally, listen actively, and provide constructive feedback. b. Collaboration Skills (25 points): The ability to work in a team, share responsibilities, appreciate the contributions of members, and resolve conflicts. c. Critical Thinking Skills (25 points): The ability to analyze tactical situations, make strategic decisions, evaluate performance, and solve problems. d. Creativity Skills (25 points): The ability to develop innovative strategies, improvise movements, and generate unique solutions. The maximum total score is 100 points. The validity of the instrument was tested through expert judgment by three Physical Education experts and one assessment expert with a Content Validity Ratio (CVR) value of 0.92. Inter-rater reliability was tested using the Intraclass Correlation Coefficient (ICC) with a value of 0.88 ($p<0.01$), indicating good consistency of assessment between raters. 2. Physical Literacy Assessment for Youth (PLAY) Tools. The Physical Literacy instrument uses PLAY Tools developed by Canadian Sport for Life and adapted for the Indonesian context (Cairney et al., 2018). PLAY Tools measure four domains of Physical Literacy: a. Physical Competence (25 points): Fundamental motor skills in athletics (running, jumping, throwing). b. Motivation and Confidence (25 points): Intrinsic motivation, self-efficacy, and perceived competence. c Knowledge and Understanding (25 points): Understanding of athletic concepts, rules, strategies, and training principles. dEngagement in Physical Activities (25 points): Active participation, persistence in the face of challenges, and a positive attitude toward physical activity. The maximum total score is 100 points. Construct validity was tested using Confirmatory Factor Analysis (CFA) with results of $\chi^2/df=2.18$, CFI=0.95, TLI=0.94, RMSEA=0.05, indicating a good model fit. Internal reliability using Cronbach's Alpha showed satisfactory values for all domains ($\alpha=0.86$-0.91).

Data Analysis Techniques. The collected data were analyzed using descriptive and inferential statistics with the help of SPSS software version 26.0. The analysis stages included 1. Normality Test: Using the Shapiro-Wilk test to test the normality of data distribution (n<50. 2. Homogeneity Test: Using Levene's test to test the homogeneity of

variance 3. Pre-test

Difference Test: Independent Sample t-test to ensure initial equality 4. Pre-test-Post-test Difference Test: Paired Sample t-test to analyze improvements in the group 5. Posttest Difference Test Between Groups: Independent Sample t-test to compare the effectiveness of the intervention 6. Effect Size: Calculating Cohen's d to measure the magnitude of the treatment effect. The significance level used is α=0.05 with a 95% confidence interval. All statistical assumptions are tested before performing inferential analysis

RESULT AND DISCUSSION

Research Subject Characteristics The characteristics of the research subjects show that of the 48 students in the sample, 26 (54.2%) were male and 22 (45.8%) were female. The average age of the subjects was 13.6 years (SD=0.52) with an age range of 13-14 years. The distribution of subject characteristics in the experimental and control groups was relatively homogeneous based on the chi-square test for the gender variable (χ^2=0.17; p=0.683) and the independent sample t-test for the age variable (t=0.38; p=0.706).

Results of Normality Assumption Test: The Shapiro-Wilk test results showed that the 4Cs Skills data in the experimental group (pretest: W=0.968, p=0.634; posttest: W=0.973, p=0.741) and the control group (pretest: W=0.965, p=0.567; posttest: W=0.970, p=0.684) is normally distributed (p>0.05). Similarly, Physical Literacy data in the experimental group (pretest: W=0.971, p=0.702; posttest: W=0.976, p=0.808) and the control group (pretest: W=0.967, p=0.608; posttest: W=0.972, p=0.723) were also normally distributed.

Homogeneity Test: The Levene test results show that the variance of the 4Cs Skills data (F=1.08; p=0.304) and Physical Literacy data (F=0.96; p=0.333) in both groups is homogeneous (p>0.05), thus fulfilling the assumption for performing a parametric test.

Description of 4Cs Skills Data

Table 1. Descriptive Statistics of 4Cs Skills

Group Measurement	N	Mean	SD	Min	Max
Experimental Pretest	24	64,25	8,67	48	79
Experimental Posttest	24	85,17	6,42	72	96
Control Pretest	24	63,83	8,92	47	78
Control Posttest	24	71,46	7,85	56	85

Based on Table 1, both groups experienced an increase in 4Cs Skills scores from the pretest to the posttest. The experimental group experienced an average increase of 20.92 points (32.56%), while the control group experienced an average increase of 7.63 points (11.95%).

Table 2. Frequency Distribution of 4Cs Skills Categories (Posttest)

Kategori	Score Range	Group Eksperimen		Group Kontrol	
		Frekuensi	Persentase	Frekuensi	Persentase
Very Good	86-100	11	45,8%	1	4,2%
Good	71-85	12	50,0%	10	41,7%
Fair	56-70	1	4,2%	12	50,0%
Poor	41-55	0	0,0%	1	4,2%
Very Poor	0-40	0	0,0%	0	0,0%
Total		24	100%	24	100%

Description of Physical Literacy Data

Table 3. Descriptive Statistics of Physical Literacy

Kategori	Score Range	Group Eksperimen		Group Kontrol	
		Frekuensi	Persentase	Frekuensi	Persentase
Very High	86-100	13	54,2%	2	8,3%
High	71-85	10	41,7%	11	45,8%
Moderate	56-70	1	4,2%	10	41,7%
Low	41-55	0	0,0%	1	4,2%
Very Low	0-40	0	0,0%	0	0,0%
Total		24	100%	24	100%

Hypothesis Test Results

Tabel 4. Results of the Pretest Difference Test Between Groups

Variabel	Group	Mean	SD	t	df	p
4Cs Skills	Eksperimen	64,25	8,67	0,167	46	0,868
	Kontrol	63,83	8,92			
Physical Literacy	Eksperimen	68,50	9,23	0,157	46	0,876
	Kontrol	68,08	9,47			

The results of the independent sample t-test in Table 5 show that there was no significant difference between the experimental and control groups in the 4Cs Skills pretest (t=0.167; p=0.868>0.05) and Physical Literacy (t=0.157; p=0.876>0.05), indicating that both groups had equivalent initial abilities

Table 5. Results of the Paired Sample t-test for the Experimental Group

Variabel	Pretest M (SD)	Posttest M (SD)	Selisih M (SD)	t	df	p	Cohen's d
4Cs Skills	64,25 (8,67)	85,17 (6,42)	20,92 (7,84)	13,058	23	<0,001	2,667
Physical Literacy	68,50 (9,23)	87,33 (7,15)	18,83 (8,45)	10,920	23	<0,001	2,230

Table 6. Results of the Paired Sample t-test for the Control Group

Variabel	Pretest M (SD)	Posttest M (SD)	Selisih M (SD)	t	df	p	Cohen's d
4Cs Skills	63,83 (8,92)	71,46 (7,85)	7,63 (6,92)	5,403	23	<0,001	0,901
Physical Literacy	68,08 (9,47)	75,67 (8,38)	7,59 (7,23)	5,143	23	<0,001	0,843

Table 7. Results of the Independent Sample t-test Posttest Between Groups

Variabel	Group	Mean	SD	t	df	p	Cohen's d
4Cs Skills	Eksperimen	85,17	6,42	6,925	46	<0,001	2,893
	Kontrol	71,46	7,85				

Physical Literacy	Eksperimen	87,33	7,15	5,784	46	<0,001	2,417
	Kontrol	75,67	8,38				

Table 8 shows a significant difference between the experimental and control groups on the posttest with a very large effect size (Cohen's d > 2.0), indicating that the Hybrid Gamification-TPACK approach has a substantial impact.

Discussion

Improvement of 4Cs Skills through Hybrid Gamification-TPACK The results showed that the Hybrid Gamification-TPACK approach was effective in improving students' 4Cs Skills by 32.56%, which was much higher than the control group (11.95%). This finding was consistent with the research which found that gamification in Physical Education improved students' basic psychological needs and positive behavior (Sotos-Martínez et al., 2024). In the context of this study, gamification elements such as team challenges and collaborative quests encourage students to communicate more effectively, share ideas, and work together to achieve common goals. The Communication Skills dimension showed a significant increase due to the learning structure that facilitated multidirectional communication. Students not only received instructions from teachers but also actively discussed with peers, provided constructive feedback, and presented team strategies. Research confirms that gamification increases student engagement through more intensive social interaction (Vega-Ramírez & Quijano-Escate, 2023). The use of the ClassDojo application facilitates digital communication that enriches students' communication repertoire, in line with the demands of multimodal 21st-century communication.

Collaboration Skills are developed through team-based quests that require students to work in groups to complete athletic challenges. Each member has a specific role (sprinter, jumper, thrower) and must collaborate to collect team points. This reflects the principle of positive interdependence in cooperative learning, which has been proven effective in developing collaboration skills (Johnson & Johnson, R. T., 2009). Research found that collaboration-based learning in Physical Education significantly improves students' social skills and teamwork (Baena-Extremera et al., 2020). Critical Thinking Skills are developed through inquiry-based challenges that require students to analyze performance, identify technical weaknesses, and devise improvement strategies. The use of video motion analysis allows students to conduct critical self-assessment and peer-assessment. These findings support the research which shows that the inquiry approach in Physical Education improves students' critical thinking and problem-solving abilities (Pill et al., 2022).

Creativity Skills develop through open-ended tasks that give students the freedom to explore a variety of techniques and strategies. Quests such as “Create Your Signature Move” encourage students to innovate with their personal athletic style. Research shows that learning that provides space for creative exploration enhances students' motor creativity and adaptability in Physical Education (Torrents et al., 2020). The TPACK framework ensures that technology integration is not superficial, but pedagogical and supports athletic content learning. The use of wearable fitness trackers to monitor heart rate and calorie burn provides real-time feedback that increases students' body awareness. QR codes scattered throughout the learning area provide instant access to technique tutorial videos, creating self-paced and differentiated learning. This is in line with the principles of Universal Design for Learning (UDL), which emphasizes the importance of multiple means of representation, expression, and engagement (Rose & Meyer, 2002).

Improvement in Physical Literacy through Hybrid Gamification-TPACK Physical Literacy in the experimental group increased by 27.49%, almost 2.5 times that of the control group (11.15%). This finding is consistent with the research which emphasizes that Physical Literacy develops optimally in a supportive, fun, and meaningful learning environment (Cairney et al., 2019). The Hybrid Gamification-TPACK approach creates all three conditions simultaneously. The Physical Competence dimension shows a substantial increase in fundamental athletic motor skills. The level progression system in gamification ensures that students practice with gradually increasing intensity and complexity, in accordance with the principle of progressive overload in motor learning (Schmidt & Lee, 2019). Each quest level is designed with clear scaffolding, facilitating students' zone of proximal development (Vygotsky, 2017). Unlike conventional drills, which are monotonous, the variety of challenges in gamification allows students to repeat tasks in different contexts, improving transfer learning and skill retention.

Motivation and confidence increase dramatically because gamification creates a transparent and attainable achievement structure. The badge system recognizes various types of achievements not only for students with high athletic ability, but also for improvement, effort, and sportsmanship. This creates multiple pathways to success that increase the self-efficacy of students with varying levels of ability. Research emphasizes that intrinsic motivation develops when the needs for autonomy, competence, and relatedness are met conditions that are facilitated by the gamification design in this study (Ryan & Deci, 2000). The leaderboard used is not purely competitive, but uses a dual-layer system: an individual leaderboard for personal achievement and a team leaderboard for collective success. This strategy reduces demotivation among students with low abilities while maintaining challenges for advanced students. warns that leaderboards can have a negative impact if not carefully designed, but in this study, the dual-layer structure

proved effective in maintaining the motivation of all students (Hanus & Fox, 2015).

Knowledge and understanding increase because learning focuses not only on "doing" but also on "understanding why and how." Each quest is accompanied by a knowledge checkpoint in the form of an interactive quiz on biomechanical concepts, training principles, and athletic history. The integration of technology such as augmented reality (AR) flashcards provides 3D visualization of movement anatomy, enhancing students' conceptual understanding. These findings are in line with research which shows that immersive technology improves cognitive engagement and knowledge retention in physical education (Robles & Estevez, 2023). Engagement in physical activities is reflected in the very high levels of student participation and persistence. Observations show that the experimental group had a very low absenteeism rate (96.7%) and students showed high enthusiasm even when faced with difficult challenges. The narrative element "Athletic Champions Journey" creates emotional investment that makes students feel part of a bigger story. Research emphasizes that Physical Literacy is not only about physical ability but also about developing a lifelong love of movementa condition facilitated by engaging and meaningful learning experiences (Whitehead, 2013).

Mechanisms of Hybrid Gamification-TPACK Effectiveness The success of the Hybrid Gamification-TPACK approach can be explained through several psychological and pedagogical mechanisms. First, gamification creates a flow experiencean optimal condition where challenge and skill are in balance (Csikszentmihalyi, 2020). Each student can choose quests according to their skill level, ensuring they do not feel bored (skill challenge) or anxious (challenge skill). This flow condition has been proven to increase enjoyment, concentration, and intrinsic motivation. Second, immediate feedback from the gamification system facilitates more effective motor learning. According to information processing theory (Fitts & Posner, 1967). timely and specific feedback accelerates error correction and refinement of motor skills. The point system provides direct quantitative feedback, while achievement badges provide qualitative feedback on milestones achieved. The video replay feature allows students to visually see their performance, increasing body awareness and self-correction ability. Third, social comparison and social learning facilitated in a team-based gamification structure enhance learning through observational learning (Bandura, 2019). Students learn not only from teacher demonstrations but also from peer modeling. Leaderboards create constructive social comparison, encouraging students to learn from more proficient students. Peer teaching integrated into team quests enhances conceptual understanding through elaborative rehearsal.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the

Hybrid Gamification-TPACK approach has been proven effective in significantly improving the 4Cs Skills and Physical Literacy of eighth-grade students in athletics learning. The experimental group showed an increase in 4Cs Skills of 32.56% and Physical Literacy of 27.49%, which was much higher than the control group that used the conventional approach (11.95% and 11.15%). The significant difference between the two groups ($p<0.001$) with a very large effect size (Cohen's $d > 2.0$) indicates that this approach has a substantial impact and high practical significance. The success of the Hybrid Gamification-TPACK approach is due to its ability to integrate the motivational elements of gamification with the pedagogical soundness of the TPACK framework. Learning becomes more engaging, meaningful, and differentiated, facilitating the development of not only motor skills but also cognitive, affective, and social skills that are essential for the 21st century.

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