JPPIPA 12(10) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

STEM-Based Gamification for Bullying Prevention: Enhancing Empathy and Social Awareness through Science Learning in Elementary Schools

Abdul Rahman[1*], Jamaludin[2], Muhammad Zaky[3], Azizah[1]

[1] Primary School Teacher Education Study Program, Faculty of Teacher Training and Education, Tadulako University, Palu, Indonesia.
[2] Civic and Citizenship Education Study Program, Faculty of Teacher Training and Education, Tadulako University, Palu, Indonesia.
[3] Physics Education Study Program, Faculty of Teacher Training and Education, Tadulako University, Palu, Indonesia.

Received: April 28, 2026
Revised: July 3, 2026
Accepted: October 12, 2026
Published: October 31, 2026

Corresponding Author:
Abdul Rahman
rahmanabdul@untad.ac.id

DOI: 10.29303/jppipa.v12i10.15110

Open Access

© 2026 The Authors. This article is distributed under a (CC-BY License)

Abstract: The study aimed to examine the effectiveness of STEM-based gamification in enhancing elementary school students' empathy and social awareness as a strategy for bullying prevention. A quantitative approach with a quasi-experimental pretest–posttest control group design was employed. The participants were 120 fifth-grade students from four elementary schools in Palu City, Indonesia, who were assigned to either an experimental group or a control group. The experimental group participated in STEM-based gamified learning, while the control group received conventional instruction. Data were collected using validated and reliable empathy and social awareness questionnaires, along with observation sheets, and were analyzed using paired-samples *t*-tests, independent-samples *t*-tests, ANCOVA, and Cohen's *d* effect size. The results indicated that the experimental group demonstrated significantly greater improvements in empathy and social awareness than the control group ($p < 0.05$). The mean empathy score increased from 68.45 to 82.73, while the mean social awareness score improved from 70.12 to 84.05, with large effect sizes. These findings suggest that integrating gamification into STEM learning creates interactive, contextual, and collaborative learning experiences that foster students' social-emotional competencies. Therefore, STEM-based gamification represents a promising science learning strategy for supporting bullying prevention in elementary schools.

Keywords: Bullying; Elementary school; Empathy; Gamification; Social awareness; STEM

Introduction

Bullying in elementary schools remains one of the major challenges in education because of its detrimental effects on students' psychological, social, and academic development (Andini et al., 2025; Li & Hesketh, 2026). Bullying is no longer limited to physical aggression but also includes verbal harassment, social exclusion, and cyberbullying, all of which have become increasingly prevalent with the rapid advancement of digital technology (Haryanto et al., 2024; Iswandi et al., 2026; Thanos & Katsikas, 2026). These consequences are particularly severe at the elementary school level, as this stage represents a critical period for developing social-emotional competencies, including empathy, social awareness, collaboration skills, and self-regulation (Syakinah et al., 2025). Deficiencies in these competencies contribute to aggressive behavior and deteriorating peer relationships, underscoring the need for early bullying prevention through systematic and well-designed educational interventions (Mayunita et al., 2024).

Various bullying prevention initiatives have been implemented through awareness campaigns, child-

How to Cite:
Rahman, A., Jamaludin, Zaky, M., & Azizah. (2026). STEM-Based Gamification for Bullying Prevention: Enhancing Empathy and Social Awareness through Science Learning in Elementary Schools. *Jurnal Penelitian Pendidikan IPA*, *12*(10), 146–154. https://doi.org/10.29303/jppipa.v12i10.15110

friendly school programs, disciplinary policies, and punitive approaches (Gaffney et al., 2019; Lestari & Firman, 2025). Although these interventions can improve students' awareness in the short term, they are generally implemented as isolated initiatives and are not sustainably integrated into everyday classroom instruction (Kurniawan, 2025). Consequently, the internalization of empathy and social awareness remains suboptimal, as students tend to act as passive recipients of information rather than active participants who develop these competencies through meaningful learning experiences (Safira & Suriani, 2025; Suwandi & Kurnia, 2025). This highlights the need for instructional strategies that not only promote cognitive development but also foster social-emotional competencies through authentic and experiential learning (Handayani & Falah, 2023).

In the context of 21st-century education, science learning is no longer solely intended to develop conceptual understanding but also to foster students' critical thinking, collaboration, communication, creativity, and character development (Hairida et al., 2026; Mukmin et al., 2024; Samodra et al., 2026). The STEM (Science, Technology, Engineering, and Mathematics) approach has been widely recognized as an effective instructional framework that connects scientific concepts with authentic problem-solving through collaborative learning activities (Apedoe et al., 2026; Astuti & Abidin, 2026; Fahira & Puspitawati, 2025; Pranata et al., 2023). However, STEM implementation in elementary schools continues to focus predominantly on cognitive outcomes, such as scientific literacy, problem-solving abilities, and technical skills, while the development of social-emotional competencies has received comparatively little attention (García-Silva et al., 2026; Jayanto & Saputro, 2026). In fact, the collaborative, decision-making, and real-world problem-solving characteristics of STEM learning provide substantial opportunities to cultivate students' empathy and social awareness (Alam et al., 2025; Padmawati et al., 2025).

On the other hand, gamification has emerged as an innovative instructional approach that enhances students' motivation, engagement, and learning experiences through the integration of game elements such as challenges, levels, rewards, and immediate feedback (Fadilla & Nurfadhilah, 2022; Hakeu et al., 2023; Lorenza et al., 2025). Numerous studies have demonstrated that gamification effectively improves learning outcomes, motivation, and student participation (Musnidar et al., 2022; Yulianti et al., 2024). However, most of this research has focused primarily on academic achievement, while the use of gamification to foster social-emotional competencies, particularly in the context of bullying prevention, remains largely underexplored (Nurhalimah et al., 2025). Consequently, the potential of gamification as a tool for character development has yet to be fully realized.

Based on the existing literature, three major research gaps can be identified. First, although STEM education has been widely recognized for enhancing students' scientific literacy, problem-solving skills, and other cognitive outcomes, relatively few studies have examined its potential to foster social-emotional competencies, such as empathy and social awareness (Bukoting, 2023; Wahyuni et al., 2026). Second, research on gamification has predominantly focused on improving students' motivation, engagement, and academic achievement, with limited attention to its role in promoting empathy and social awareness as essential components of character development (Aulia et al., 2024). Third, studies integrating STEM education, gamification, and bullying prevention into a comprehensive instructional framework for elementary school students remain scarce, leaving limited empirical evidence regarding the effectiveness of such an integrated approach in promoting students' social-emotional development through science learning (Nazara & Daeli, 2026). These gaps highlight the need for empirical research investigating how the integration of STEM and gamification can simultaneously enhance science learning and strengthen students' character development, particularly empathy and social awareness, as preventive measures against bullying.

This study offers novelty in both its conceptual and practical dimensions. Conceptually, it integrates STEM education, gamification, and character education into a unified instructional framework designed to foster empathy and social awareness as key competencies for bullying prevention. Practically, the study develops STEM-based gamified learning activities that simulate social situations related to bullying, enabling students not only to learn scientific concepts but also to practice decision-making, understand others' perspectives, and reflect on the consequences of their actions through contextual and experiential learning. Unlike previous studies that have primarily focused on academic outcomes, this study simultaneously evaluates the effectiveness of the instructional approach in enhancing two essential social-emotional competencies: empathy and social awareness.

The significance of this study lies in the urgent need for instructional models that can address the demands of 21st-century education more comprehensively by integrating knowledge acquisition, higher-order thinking skills, and character

development within a unified learning process. The findings are expected not only to advance the body of knowledge on the integration of STEM education and gamification in elementary education but also to provide empirical evidence that science learning can serve as a strategic platform for fostering a safe, inclusive, and bullying-free school environment. Accordingly, this study aims to examine the effectiveness of STEM-based gamification in enhancing students' empathy and social awareness as a preventive strategy against bullying in elementary schools.

Method

This study employed a quantitative approach using a quasi-experimental pretest–posttest control group design to examine the effectiveness of STEM-based gamification in enhancing students' empathy and social awareness as a strategy for bullying prevention in elementary schools. The study involved two groups: an experimental group and a control group. The experimental group received STEM-based gamified instruction, whereas the control group participated in conventional science instruction following the teaching practices routinely implemented by classroom teachers. This design was selected because it enables comparisons of changes in students' outcomes before and after the intervention across both groups, thereby providing a more accurate evaluation of the intervention's effects under authentic classroom conditions. The research procedure began with sample selection, followed by instrument development and validation, pretest administration, a four-week instructional intervention, classroom observations throughout the learning process, post test administration, and data analysis. The overall research procedure is illustrated in Figure 1.

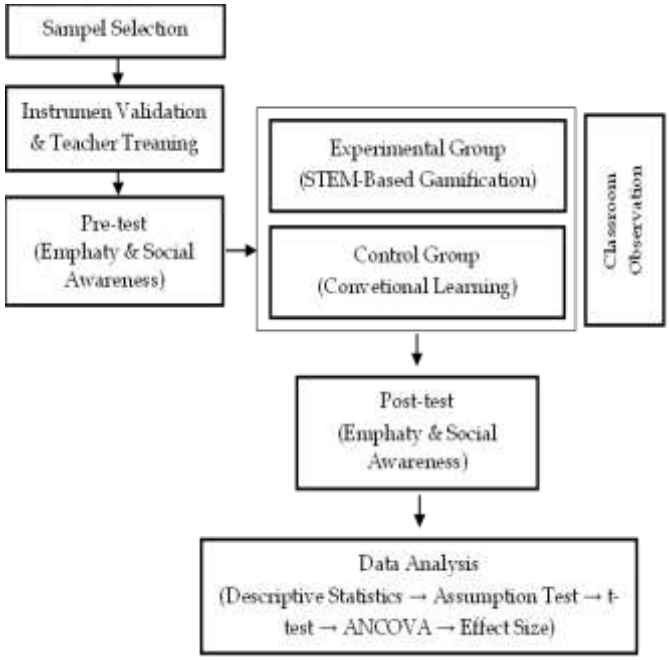

Figure 1. Research flowchart of the STEM-based gamification intervention

The participants consisted of 120 fifth-grade students from four elementary schools in Palu City, Central Sulawesi, Indonesia. The sample was selected using purposive sampling based on the similarity of school characteristics, including accreditation status, implementation of the Merdeka Curriculum, students' socioeconomic backgrounds, and the availability of learning facilities. Of the total participants, 60 students were assigned to the experimental group and 60 to the control group. The students were between 10 and 11 years of age, a developmental stage that is critical for the development of social-emotional competencies. Prior to the implementation of the study, teachers from both groups participated in a brief training session on the instructional materials and procedures to ensure that the intervention was delivered consistently and in accordance with the research protocol.

The intervention was implemented over a four-week period, comprising eight instructional sessions in the fifth-grade Science and Social Studies (IPAS) subject on the topic of environmental conservation and waste management. This topic was selected because it provides meaningful opportunities to integrate STEM concepts with real-world social issues that are relevant to students' daily lives. The Science component focused on understanding different types of waste, environmental pollution, and their impacts on living organisms. The Technology component involved the use of digital media and a gamification platform to support the completion of learning missions. The Engineering component engaged students in designing simple solutions, such as prototypes of

environmentally friendly waste bins or school waste management systems. The Mathematics component required students to collect, classify, and analyze waste observation data using tables and graphs. Learning activities were structured as missions and challenges, incorporating game elements such as points, badges, levels, and immediate feedback. Each mission also included simulations of social situations related to bullying prevention, such as collaborating in groups, respecting peers' opinions, supporting classmates who encountered difficulties, and resolving conflicts through discussion. These activities enabled students to integrate science problem-solving with the development of empathy and social awareness through authentic learning experiences.

To minimize the influence of extraneous variables on the study outcomes, several control measures were implemented. Both the experimental and control groups received the same IPAS content, the same number of instructional sessions, identical instructional time, and were taught by teachers with comparable teaching experience. In addition, the participating schools ensured that neither group participated in any supplementary bullying prevention programs during the study period, such as seminars, character education workshops, or specialized counseling sessions that could potentially influence students' empathy and social awareness. Furthermore, equivalent instructional materials were developed for both groups, with comparable learning objectives, content, and assessment procedures. These measures were intended to ensure that any differences in the study outcomes could be more confidently attributed to the implementation of STEM-based gamification rather than to external factors.

The research instruments consisted of an empathy questionnaire, a social awareness questionnaire, and a student behavior observation checklist. The empathy questionnaire was developed based on indicators of perspective taking, empathic concern, and emotional responsiveness to social situations. The social awareness questionnaire assessed students' sensitivity to their social environment, respect for diversity, collaboration skills, and concern for their peers. Both questionnaires employed a five-point Likert scale and underwent content validity evaluation by three experts in elementary education, followed by reliability testing using Cronbach's alpha prior to data collection. The observation checklist was used to document students' behaviors during the learning process, including collaboration, respect for peers' opinions, helping behaviors, conflict resolution, and indications of bullying. Observations were conducted by two independent observers: a classroom teacher who was not directly involved in the intervention and a research assistant who had received training in the use of the observation instrument. Before the observations began, both observers participated in an observer calibration session to establish a shared understanding of the assessment criteria, thereby ensuring consistency in ratings and enhancing the objectivity of the observational data.

Data were analyzed using statistical software with a significance level of 0.05. The analysis began with descriptive statistics to summarize the mean, standard deviation, minimum and maximum values, and data distribution for each research variable. This was followed by preliminary assumption testing, including the Shapiro–Wilk test for normality, Levene's test for homogeneity of variances, a test of linearity between pretest and posttest scores, and the homogeneity of regression slopes test as a prerequisite for conducting Analysis of Covariance (ANCOVA). After all assumptions were satisfied, paired-samples t-tests were performed to examine score improvements within each group, while independent-samples t-tests were used to compare outcomes between experimental and control groups. In addition, ANCOVA was conducted using pretest scores as a covariate to control differences in students' initial abilities, thereby providing a more accurate estimate of the intervention's effect. Finally, Cohen's d was calculated to determine the magnitude of the intervention effect and evaluate the effectiveness of STEM-based gamification in enhancing students' empathy and social awareness.

Result and Discussion

The findings of this study are presented in Table 1, which summarizes the analysis of students' empathy and social awareness scores obtained from the pretest and posttest in both the experimental and control groups. Overall, the results indicate that the experimental group demonstrated significantly greater improvements than the control group following the implementation of the STEM-based gamified learning intervention.

Table 1. Results of the Analysis of Students' Empathy and Social Awareness Data (Pretest and Posttest)

Variable	Groups	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Empathy	Experimental	60	68.45	6.21	82.73	5.87
	Control	60	67.92	6.34	73.15	6.01
Social Awareness	Experimental	60	70.12	5.98	84.05	5.65
	Control	60	69.88	6.10	74.62	5.89

The descriptive analysis revealed that the mean scores for both empathy and social awareness increased from the pretest to the posttest in both groups, with substantially greater improvements observed in the experimental group than in the control group. In addition, the Standard Deviations (SD) in the experimental group decreased following the intervention, indicating that students' improvements were not only greater overall but also more consistent, with reduced variability in scores across participants. The mean empathy score in the experimental group increased from 68.45 (SD = 6.21) at the pretest to 82.73 (SD = 5.87) at the posttest, whereas the control group showed an increase from 67.92 (SD = 6.34) to 73.15 (SD = 6.01). Similarly, the mean social awareness score in the experimental group rose from 70.12 (SD = 5.98) to 84.05 (SD = 5.65), while the control group improved from 69.88 (SD = 6.10) to 74.62 (SD = 5.89). The reduction in standard deviations within the experimental group suggests that the effects of STEM-based gamified learning were distributed relatively evenly among students, resulting not only in higher average achievement but also in more consistent development of empathy and social awareness compared with conventional instruction.

The results of the Kolmogorov–Smirnov normality test indicated that all variables were normally distributed ($p > 0.05$). The Levene's test for homogeneity of variances also confirmed that the data were homogeneous ($p > 0.05$). Therefore, the assumptions for parametric statistical analyses were satisfied, allowing parametric tests to be used for hypothesis testing. The results of the paired-samples t-test revealed significant improvements in the experimental group for both empathy ($t = 12.45$, $p < 0.001$) and social awareness ($t = 13.21$, $p < 0.001$). The results of the hypothesis testing are presented in Table 2.

Table 2. Results of the Paired Samples t-Test Hypothesis Testing

Variable	Groups	t	Sig. (p-value)	Notes
Empathy	Experimental	12.45	0.000	Significant
	Control	5.12	0.000	Significant
Social Awareness	Experimental	13.21	0.000	Significant
	Control	4.87	0.000	Significant

Meanwhile, the control group also demonstrated statistically significant improvements, although the magnitude of these gains was smaller than that observed in the experimental group (empathy: $t = 5.12$, $p < 0.001$; social awareness: $t = 4.87$, $p < 0.001$). The improvement in the control group may be attributed to the regular instructional activities that continued throughout the study, as well as possible maturation effects, reflecting the natural development of students' social-emotional competencies over time, and pretest effects, whereby completing the initial assessment may have increased students' awareness of empathetic behavior and social interactions. Nevertheless, as presented in Table 2, the results of the independent-samples t-test on the posttest scores showed that the experimental group achieved significantly higher scores than the control group for both empathy ($t = 8.37$, $p < 0.001$) and social awareness ($t = 9.12$, $p < 0.001$). These findings indicate that the improvements observed in the experimental group cannot be explained solely by regular classroom instruction or students' natural development but instead suggest a stronger contribution of the STEM-based gamification intervention to the enhancement of students' empathy and social awareness.

Further analysis using ANCOVA, with pretest scores controlled as a covariate, revealed that the treatment effect remained statistically significant for both empathy ($F = 45.76$, $p < 0.001$) and social awareness ($F = 52.13$, $p < 0.001$). These findings indicate that the observed differences in posttest outcomes were not attributable to students' initial levels but rather to the intervention itself. Furthermore, the Cohen's d effect size analysis demonstrated large treatment effects, with $d = 1.12$ for empathy and $d = 1.25$ for social awareness. These effect sizes indicate that the STEM-based gamification intervention had a substantial impact on enhancing both students' empathy and social awareness.

Table 3. Results of the Independent Samples t-Test Hypothesis Testing

Variable	t	Sig. (p-value)	Notes
Empathy	8.37	0.000	Significant
Social Awareness	9.12	0.000	Significant

The findings of this study demonstrate that STEM-based gamified learning significantly enhanced

elementary school students' empathy and social awareness. Although the control group also showed statistically significant improvements, the magnitude of these gains was substantially smaller than that of the experimental group. This improvement may be attributed to regular classroom instruction, the natural development of students' social-emotional competencies, and possible pretest effects. Nevertheless, the results of the independent samples t-test revealed that the experimental group achieved significantly higher posttest scores than the control group, while ANCOVA, controlling pretest scores, confirmed that these differences remained statistically significant. These findings suggest that integrating gamification into STEM-based science learning creates more meaningful learning experiences and contributes positively to the development of students' affective competencies (Khafidh et al., 2025). Through gamification elements such as challenges, rewards, and immediate feedback, students are encouraged to participate more actively, thereby enhancing their motivation, engagement, and the quality of their social interactions (Suparmini et al., 2024).

The improvement in empathy observed in the experimental group can be explained by the integration of STEM components with gamification mechanisms. Within the Science component, students explored environmental conservation and waste management through authentic real-world problems that illustrated the relationship between human behavior and its impact on both the environment and society, thereby fostering a sense of social responsibility and concern for others. In the Technology component, the use of digital media and interactive simulations enabled students to visualize bullying scenarios and their consequences for victims. These learning experiences helped students develop perspective-taking skills, understand the emotional experiences of others, and reflect on the consequences of their own actions. This process is consistent with experiential learning theory, which posits that empathy is cultivated through direct experience, critical reflection, and meaningful interaction in contexts that closely resemble real-life situations.

Furthermore, the improvement in social awareness indicates that students became more sensitive to social norms and interpersonal interactions within their environment (Kadhafi, 2024; Oktaviani, 2025). The contribution of STEM to the development of social awareness was also evident in the Engineering and Mathematics components. Through collaborative activities involving the design of solutions to environmental problems, students learned to communicate effectively, respect differing opinions, build consensus, and resolve conflicts constructively. Meanwhile, the Mathematics component required students to analyze and interpret data collected from environmental observations, encouraging them to make evidence-based decisions while considering the social implications of the proposed solutions. The integration of these four STEM components was further enhanced through gamification elements, including missions, levels, badges, points, and immediate feedback, providing students with more interactive, contextualized, and meaningful learning experiences (Rahmatiah et al., 2023; Rahmawati, 2025; Suparmini et al., 2024).

Compared with conventional instruction, this approach proved to be more effective because it integrates cognitive, affective, and social dimensions within a single learning process. Conventional instruction tends to emphasize the delivery of conceptual knowledge and academic exercises, providing relatively limited opportunities for students to engage in social situations that require empathy, collaboration, and reflection. In contrast, STEM-based gamified learning enables students to learn through authentic problem-solving, actively collaborate with peers, and receive immediate feedback on the decisions they make. Consequently, although both groups demonstrated improvement, the results of the independent-samples t-test and ANCOVA indicated that the STEM-based gamification intervention made a significantly greater contribution to the enhancement of students' empathy and social awareness than conventional instruction.

The findings of this study reinforce previous research demonstrating that gamification can enhance students' motivation, engagement, and learning outcomes (Suparmini et al., 2024; Yulianti et al., 2024). More importantly, this study extends the existing body of knowledge by showing that when gamification is integrated with a STEM approach grounded in contextual problem-solving, its benefits extend beyond cognitive achievement to foster social-emotional competencies, particularly empathy and social awareness, which are fundamental to bullying prevention in elementary schools. Therefore, this study provides empirical evidence that the integration of STEM and gamification represents an instructional approach that not only enhances the quality of science learning but also strengthens students' character development through collaborative, reflective, and contextualized learning experiences.

Nevertheless, this study has several limitations, including the relatively short duration of the intervention and the sample being limited to elementary schools in Palu City, Indonesia. Therefore,

future research is recommended to implement the intervention over a longer period, involve more diverse samples, and examine the sustainability of improvements in empathy and social awareness through longitudinal studies. Overall, the findings indicate that STEM-based gamification is an effective instructional strategy for enhancing students' empathy and social awareness as a preventive measure against bullying. These findings contribute theoretically to the advancement of STEM education by emphasizing the development of social-emotional competencies, while also offering practical implications for teachers in designing science learning that is more contextualized, inclusive, and oriented towards character development.

Conclusion

This study demonstrates that the implementation of STEM-based gamification in elementary school science learning is more effective than conventional instruction in enhancing students' empathy and social awareness, as evidenced by the significant differences between the experimental and control groups and supported by large effect sizes. These findings suggest that integrating gamification elements with contextual and collaborative STEM activities can serve as an effective instructional strategy for fostering students' social-emotional competencies while supporting bullying prevention efforts. Therefore, elementary school teachers are encouraged to intentionally incorporate authentic problem-solving activities, simulations, collaborative learning, and gamification elements into science instruction, enabling students not only to master scientific concepts but also to develop empathy and social awareness through meaningful learning experiences. Nevertheless, the effectiveness of this approach depends on the quality of instructional design, students' characteristics, and the specific school context; therefore, its implementation should be adapted to the needs and conditions of each educational setting. Future research is recommended to involve larger and more diverse samples, extend the duration of the intervention, and investigate the long-term sustainability of improvements in empathy and social awareness through longitudinal studies, thereby providing more comprehensive empirical evidence regarding the effectiveness of STEM-based gamification across diverse elementary education contexts.

Acknowledgments
The authors would like to express their sincere gratitude to the Faculty of Teacher Training and Education, Tadulako University, for the institutional support and academic guidance provided throughout this research. The authors also appreciate the valuable contributions of lecturers, school partners, and all participants who were involved in this study. Their support and cooperation have been essential to the successful completion of this research.

Author Contributions
Conceptualization, AR and J; methodology, AR and MZ; software, MZ; validation, J, MZ, and A; formal analysis, AR; investigation, AR and A; resources, J; data curation, MZ; writing—original draft preparation, AR; writing—review and editing, J and A; visualization, MZ; supervision, J; project administration, AR; funding acquisition, J. All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

References

Alam, S. R., Siswanto, D. H., & Aprilia, D. (2025). Implementasi pembelajaran STEM terintegrasi computational thinking untuk meningkatkan kemampuan pemecahan masalah murid. *Papanda Journal of Mathematics and Science Research*, *4*(1), 38–48. https://doi.org/10.56916/pjmsr.v4i1.1130

Andini, N., Hafizhah, N. N., Meylani, N. I., & Kurnia, R. (2025). Dampak sosial dan psikologis bullying pada anak sekolah dasar. *Jurnal Basicedu*, *9*(6), 1779–1787. https://doi.org/10.31004/basicedu.v9i6.10833

Apedoe, X. S., Nielsen, K., Smith, R., Allen, J., Arriaga, S. P. S., & Kaelin, J. (2026). The cellular construction workshop: an integrated stem teacher–student co-learning experience. *Discover Education*, *5*(1), 237. https://doi.org/10.1007/s44217-026-01197-3

Astuti, I. P., & Abidin, Z. (2026). Analisis bibliometrik tren stem dalam pembelajaran biologi. *Edutech: Jurnal Inovasi Pendidikan Berbantuan Teknologi*, *6*(1), 161–172. https://doi.org/10.51878/edutech.v6i1.9074

Aulia, L. R., Kholisoh, N., Rahma, V. Z., Rostika, D., & Sudarmansyah, R. (2024). Pentingnya pendidikan empati untuk mengurangi kasus bullying di sekolah dasar. *Morfologi : Jurnal Ilmu Pendidikan, Bahasa, Sastra Dan Budaya*, *2*(1), 71–79. https://doi.org/10.61132/morfologi.v2i1.291

Bukoting, S. (2023). Integrasi pendidikan karakter dalam pembelajaran pendidikan kewarganegaraan untuk mengembangkan karakter siswa sekolah dasar. *Educator: Jurnal Inovasi Tenaga Pendidik Dan Kependidikan*, *3*(2), 70–82. https://doi.org/10.51878/educator.v3i2.2389

Fadilla, D. A., & Nurfadhilah, S. (2022). Penerapan gamification untuk meningkatkan motivasi belajar siswa dalam pembelajaran jarak jauh. *Inovasi Kurikulum*, *19*(1), 33–43. https://doi.org/10.17509/jik.v19i1.42778

Fahira, A. P., & Puspitawati, R. P. (2025). Analisis trend bibliometrik stem dalam pembelajaran biologi untuk melatihkan kemampuan berpikir kritis. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *14*(1), 260–269. https://doi.org/10.26740/bioedu.v14n1.p260-269

Gaffney, H., Ttofi, M. M., & Farrington, D. P. (2019). Evaluating the effectiveness of school-bullying prevention programs: An updated meta-analytical review. *Aggression and Violent Behavior*, *45*, 111–133. https://doi.org/10.1016/j.avb.2018.07.001

García-Silva, E., García-Holgado, A., Sánchez-Gómez, M. C., & Verdugo-Castro, S. (2026). Culturally responsive challenge-based STEM education: A pre–post study with rural and Indigenous primary students in Mexico. *Social Sciences & Humanities Open*, *13*, 102946. https://doi.org/10.1016/j.ssaho.2026.102946

Hairida, H., Erlina, E., Hartoyo, A., Ghasya, D. A. V., Muskania, R. T., Mariyam, S., Fatmadiwi, A., Kurniawan, R., & Arifiyanti, F. (2026). Science concept mapping in local cultural practices as a conceptual basis for active learning and contextual assessment. *Discover Education*, *5*(1), 557. https://doi.org/10.1007/s44217-026-01581-z

Hakeu, F., Pakaya, I. I., & Tangkudung, M. (2023). Pemanfaatan media pembelajaran berbasis gamifikasi dalam proses pembelajaran di mis terpadu al-azhfar. *Awwaliyah: Jurnal Pendidikan Guru Madrasah Ibtidaiyah*, *6*(2), 154–166. https://doi.org/10.58518/awwaliyah.v6i2.1930

Handayani, A. A., & Falah, F. (2023). Bullying prevention in schools: evaluating social, economic, and technological interventions. *Journal of Health Literacy and Qualitative Research*, *3*(2), 85–98. https://doi.org/10.61194/jhlqr.v3i2.529

Haryanto, S., Lestari, R. P. M., & Anif, S. (2024). Measuring students' understanding of concepts, law, and the impact of bullying. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 7512–7519. https://doi.org/10.29303/jppipa.v10i10.8604

Iswandi, Nasution, S. A., Citrowati, E., Dina Septiana, Y., & Salman. (2026). Cyberbullying pada anak sekolah dasar: studi fenomena di era digital. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *11*(01), 191–207. https://doi.org/10.23969/jp.v11i01.42093

Jayanto, P., & Saputro, T. V. D. (2026). Implementasi stem di sekolah dasar dalam menghadapi tantangan pembelajaran dan pendekatan pendidikan abad ke 21. *Elementary: Jurnal Inovasi Pendidikan Dasar*, *6*(2), 252–262. https://doi.org/10.51878/elementary.v6i2.9443

Kadhafi, M. (2024). Menilai kesadaran sosial siswa melalui pembelajaran kontekstual mata pelajaran ips. *Dinamika Sosial: Jurnal Pendidikan Ilmu Pengetahuan Sosial*, *3*(3), 314–323. https://doi.org/10.18860/dsjpips.v3i3.13167

Khafidh, A. N., Widyawati, F., Najarudin, Selvi Yani, Yeni Nuraeni, Indrawati, Inesrawanti, V., Salam, H. A., & Damayanti, F. (2025). Pemanfaatan game-based learning dan gamifikasi adaptif dalam pembelajaran STEM. *Jurnal Pengabdian Masyarakat Dan Riset Pendidikan*, *4*(2), 9468–9477. https://doi.org/10.31004/jerkin.v4i2.3419

Kurniawan, K. (2025). Krisis bullying di lingkungan sekolah dasar terpadu dan urgensi intervensi komprehensif. *Jurnal Studi Pendidikan Dasar*, *3*(2), 194–221. https://doi.org/10.54180/jsped.2025.3.2.194-221

Lestari, E. E., & Firman. (2025). The effectiveness of learning using comic media in reducing bullying in class v elementary school. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 10–15. https://doi.org/10.29303/jppipa.v11i5.11173

Li, J., & Hesketh, T. (2026). Intervention to address bullying in primary schools in rural China: implementing a social emotional learning (SEL) program. *BMC Psychology*, *14*(1), 598. https://doi.org/10.1186/s40359-026-04261-7

Lorenza, D., Istikharah, I., Rahmayanti, N., Wahyuda, A., & Taufiqurrahman, M. (2025). Penerapan gamifikasi untuk meningkatkan motivasi belajar PAI di SMP 15 kota bengkulu. *Educatoria : Jurnal Ilmiah Ilmu Pendidikan*, *5*(3), 192–201. https://doi.org/10.36312/educatoria.v5i3.576

Mayunita, A., Bintang, N., Dila, P., Putri, A., Rachmawati, R., Wardah, & Nurkamileti, W. (2024). Exploring developmental biology: the influence of sexual education and social awareness on elementary school children. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10341–10347. https://doi.org/10.29303/jppipa.v10i12.8702

Mukmin, Subakti, H., Zainuri, H., & Yusuf, B. (2024). *Inovasi Pembelajaran di Abad 21*. Yayasan Kita Menulis.

Musnidar, L., Halim, A., Huda, I., Syukri, M., & Kasli, E. (2022). Pengaruh media gamification dalam jaringan terhadap hasil belajar dan sikap berpikir dalam belajar. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 1005–1011. https://doi.org/10.29303/jppipa.v8i2.1321

Nazara, R. G., & Daeli, M. (2026). Integrasi pendekatan pembelajaran stem pada kerangka tpack di

sekolah dasar : tinjauan literatur sistematis. *Didaktika: Jurnal Kependidikan*, *15*(1), 397–410. https://doi.org/10.58230/27454312.3574

Nurhalimah, N., Rahayu, D. A., Mubin, M. F., & Hidayati, E. (2025). Fun-learning: permainan edukatif sebagai media pencegahan bullying pada anak usia sekolah. *Jurnal Pengabdian Masyarakat Bangsa*, *3*(6), 2714–2719. https://doi.org/10.59837/jpmba.v3i6.2809

Oktaviani, A. M. (2025). Pembelajaran ilmu sosial berbasis lingkungan sebagai upaya meningkatkan kesadaran sosial siswa sekolah dasar. *Journal of Humanities, Social Sciences, and Education*, *1*(3), 105–117. https://doi.org/10.64690/jhuse.v1i3.53

Padmawati, K., Suyanto, S., Pertiwi, K. R., & Wulan, A. N. (2025). The impact of STEM education on critical thinking skills: a systematic literature review. *Jurnal Penelitian Pendidikan IPA*, *11*(12), 43–51. https://doi.org/10.29303/jppipa.v11i12.13397

Pranata, R., Syahril, & Megahati S., R. R. P. (2023). Stem education in science learning: systematic literature review. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 424–431. https://doi.org/10.29303/jppipa.v9i8.4655

Rahmatiah, R., Rokhmat, J., Jufri, A. W., Gunawan, & Sukarso, AA. (2023). Science learning gamification: perspectives in building student creativity. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 981–991. https://doi.org/10.29303/jppipa.v9i11.4274

Rahmawati, E. (2025). Integrasi gamifikasi pada pembelajaran berbasis deep learning di sekolah dasar. *Tarunateach: Journal of Elementary School*, *3*(2), 136–146. https://doi.org/10.54298/tarunateach.v3i2.655

Safira, I. A., & Suriani, A. (2025). Masalah perundungan (bullying) di sd dan cara pencegahannya. *Jurnal Nakula : Pusat Ilmu Pendidikan, Bahasa Dan Ilmu Sosial*, *3*(4), 322–329. https://doi.org/10.61132/nakula.v3i4.2018

Samodra, I., Rahmawati, F., & Prayitno, B. A. (2026). A decade of advancing creative thinking skills in science education: trends and research frontiers from a bibliometric analysis (2015–2025). *Discover Education*, *5*(1), 116. https://doi.org/10.1007/s44217-026-01139-z

Suparmini, K., Suwindia, I. G., & Ari Winangun, I. M. (2024). Gamifikasi untuk meningkatkan motivasi belajar siswa di era digital. *Education and Social Sciences Review*, *5*(2), 145–148. https://doi.org/10.29210/07essr500200

Suwandi, & Kurnia, H. (2025). Perundungan di Sekolah sebagai indikator kegagalan internalisasi etika sosial: implikasinya terhadap kualitas sumber daya manusia. *Journal of Contemporary Issues in Primary Education*, *3*(2), 138–148. https://doi.org/10.61476/wqg5qv42

Syakinah, N. S., Fortuna, B., & Subrata, A. (2025). Pengaruh bullying terhadap perkembangan sosial-emosional pada anak sekolah dasar negeri 14 indralaya. *Jurnal Aksi Dosen Dan Mahasiswa*, *3*(2), 85–97. https://doi.org/10.61994/jadmas.v3i2.1213

Thanos, T., & Katsikas, A. (2026). School bullying in primary education: forms and frequency of occurrence. *International Electronic Journal of Elementary Education*. https://doi.org/10.26822/iejee.2026.459

Wahyuni, E. S., Nur Budiman, F., Nurul Huda, S., Ramdhan Yusuf, M., & Mukafasyadiah, D. (2026). Penguatan pembelajaran STEM melalui gamifikasi digital di sanggar bimbingan sentul, kuala lumpur, malaysia. *Journal of Approriate Technology for Community Services*, *7*(1), 73–85. https://doi.org/10.20885/jattec.vol7.iss1.art8

Yulianti, Y., Muslimah, & Abdullah. (2024). Gamifikasi sebagai pendekatan inovatif untuk peningkatan pemahaman siswa. *Jurnal Intelektualita: Keislaman, Sosial Dan Sains*, *13*(2). https://doi.org/10.19109/intelektualita.v13i2.24904