ISEJ Indonesian Science Education Journal

ISSN Online: 2716-3350
Vol. 4 No. 2 May 2025 Pages 62-69
https://siducat.org/index.php/isej/
Published by Yayasan Darussalam Bengkulu

Enchancing Science Learning Outcomes through the Snowball Throwing Strategy: A Classroom Action Research in Indonesian Primary Schools

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Abstract
This study examines the effectiveness of the Snowball Throwing cooperative learning strategy in improving science learning outcomes among fourth-grade students at MI Ma'arif Pabelan, Central Java, Indonesia. A classroom action research design was applied over three cycles, each consisting of planning, implementation, observation, and reflection. The participants included 33 students (22 males and 11 females). Data were gathered through achievement tests, structured observations, and documentation, and were analyzed using descriptive statistics. The results revealed steady improvements in student mastery: 51.51% in Cycle I, 69.69% in Cycle II, and 87.87% in Cycle III, surpassing both the minimum competency standard (65) and the classical completeness benchmark (85%). These findings confirm that Snowball Throwing is effective in enhancing engagement and learning achievement, especially in teaching conceptually abstract science topics such as the Earth's appearance and celestial motion. The study contributes to the literature by documenting iterative improvements across multiple cycles, highlighting its applicability in underrepresented contexts such as Islamic elementary schools. Beyond affirming the value of cooperative learning, this research emphasizes the importance of reflective teaching practices and iterative instructional refinement in achieving sustainable improvements in science education.

Keywords: Classroom Action Research; Cooperative Learning; Science Education; Snowball Throwing.

INTRODUCTION

Underpinned by global commitments to quality and equity, contemporary education is expected to cultivate learners' cognitive, social, and practical competencies for meaningful participation in society and sustainable development (Education at a Glance, 2019; Saini et al., 2023). Within this mandate, primary science education plays a crucial role because it develops foundational scientific literacy alongside twenty-first-century capacities such as reasoning with evidence, problem solving, and collaborative inquiry (Iwuanyanwu, 2020; Soomro et al., 2025; Urdanivia Alarcon et al., 2023). Yet, classroom practice in many systems including those in low- and middle-income contexts, continues to be dominated by teacher-centered transmission that limits student talk, active engagement, and formative feedback, thereby constraining the development of higher-order thinking (Bremner et al., 2022; Popova et al., 2022). Addressing this gap requires pedagogies that structure participation, elicit student thinking, and make learning visible through interaction and feedback cycles (Bremner et al., 2022; Chan, 2023; Popova et al., 2022).

A substantial body of research demonstrates that active learning approaches where students do cognitively demanding work with ideas rather than passively receiving information produce significant gains in achievement and reduce inequities (Bremner et al., 2022; Kozanitis & Nenciovici, 2023; Popova et al., 2022). In science and STEM classrooms, active learning outperforms lecture on concept inventories and examinations while narrowing performance gaps for historically underserved learners (Sandrone et al., 2021; Theobald et al., 2020; Von Korff et al., 2016). Closely aligned are inquiry-oriented and cooperative learning designs that organize peer

interaction around tasks requiring explanation, argumentation, and shared responsibility, yielding reliable improvements in conceptual understanding and persistence (Gillies, 2023; Li et al., 2023). For younger learners in particular, instruction that leverages playfulness, collaboration, and game-like structures sustains attention and deepens engagement, thereby supporting robust learning processes (Adipat et al., 2021; Rivera & Garden, 2021).

Within the cooperative learning repertoire, the Snowball Throwing strategy (sometimes called "snowball fight" questioning) operationalizes active engagement by asking students to author questions on a target concept, exchange them via "paper snowballs," and respond collaboratively, thus distributing dialogue and formative assessment across the class (Bukit et al., 2023; Hardiansyah, 2022; Manurung et al., 2019). Evidence from classroom studies indicates that Snowball Throwing increases participation, elevates motivation, and improves science learning outcomes in primary settings (Irawahyuni et al., 2021; Murtini et al., 2022). Additional investigations in Indonesian elementary schools report positive effects on achievement and classroom climate, suggesting the method's promise for contexts where student talk is typically sparse (Theobald et al., 2020; William et al., 2020). The strategy is theoretically consonant with visible-learning principles emphasizing frequent checks for understanding and peer-mediated feedback, as well as with social interdependence theory, which links structured cooperation to higher achievement and prosocial norms (Carless & Boud, 2018; Panadero & Lipnevich, 2022)

Despite these encouraging findings, several limitations in the literature remain. First, most published studies on Snowball Throwing in science involve single-site cases or short-duration implementations, which makes it difficult to trace progressive change in mastery and enact iterative refinements typical of improvement-oriented (Bergmark, 2023; Chua et al., 2022; Mertler, 2021). Second, few studies have focused on conceptually abstract and astronomy-related primary topics such as changes in Earth's appearance and celestial motions that are known to challenge learners' everyday conceptions and demand carefully scaffolded discussion (Bergmark, 2023; Raviv & Dadon, 2021). Third, evidence from Islamic elementary schools in Indonesia remains underrepresented in international discourse, even though contextual factors (school culture, curricular emphases, and resource constraints) may shape the enactment and effects of cooperative strategies (Chua et al., 2022; Nasution, 2017; Santosa & Sudirman, 2023). These gaps point to the need for methodologically transparent, multi-cycle classroom action research (CAR) that documents instructional adjustments across cycles and links them to changes in student outcomes (Kamarudin & Mat Noor, 2024; Ng & Lo, 2022).

Responding to these needs, the present study conducts a three-cycle CAR in a fourth-grade class at an Indonesian Islamic elementary school to examine the effectiveness of the Snowball Throwing strategy for improving science learning outcomes on the topic of changes in Earth's appearance and celestial bodies. Specifically, this research (a) implements Snowball Throwing with iterative refinements across cycles, (b) monitors shifts in class mastery relative to the school's competency benchmark through descriptive analysis, and (c) interprets learning gains in relation to active and cooperative learning theory and prior empirical work. By providing context-sensitive, cycle-by-cycle evidence, the study aims to strengthen the empirical base for Snowball Throwing in primary science and to offer practical guidance for teachers working in comparable school settings (Crawford, 2022; Mertler, 2021; Wakeman et al., 2022).

METHODS

This study employed a Classroom Action Research (CAR) design to systematically investigate and improve instructional practices through iterative cycles of planning, implementation, observation, and reflection. CAR was selected because it provides a structured framework for teachers and researchers to collaboratively identify instructional challenges, implement targeted strategies, and monitor their impact on student learning outcomes in real classroom contexts (Mertler, 2021). The intervention was conducted over three consecutive cycles in a fourth-grade science class at MI Ma'arif Pabelan, Central Java, Indonesia, during the 2022/2023 academic year. The participants consisted of 33 students (22 males and 11 females) and one classroom teacher who also served as a collaborator in planning and reflecting upon each cycle. The topic of focus was "Changes in the Appearance of the Earth and Celestial

Bodies," a subject area that students often find abstract and conceptually challenging.

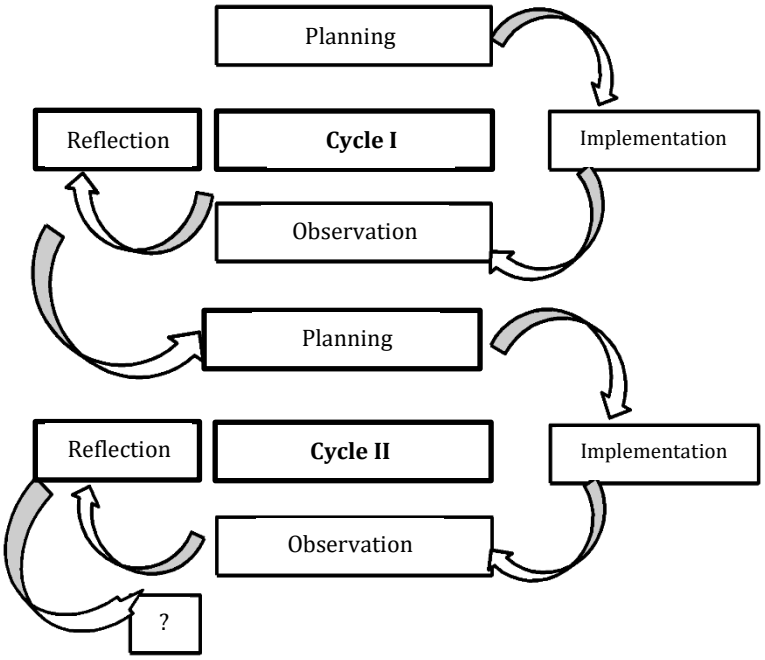

Figure 1. Classroom Action Research Cycle (Kemmis et al., 2014)

Data collection relied on multiple instruments to ensure validity and reliability. Learning outcomes were assessed using teacher-developed science achievement tests that were aligned with the school's curriculum and validated by two independent experts in science education. Student engagement and classroom dynamics were documented through structured observation checklists, while field notes and reflective journals captured qualitative insights into student participation and teacher practices. Each cycle lasted two sessions (2 × 35 minutes per session), and student mastery was evaluated against the school's Minimum Competency Criterion (*Kriteria Ketuntasan Minimal/KKM*), set at 65. Following each cycle, researchers and the classroom teacher collaboratively reflected on the findings to design refinements for subsequent implementation.

Data analysis combined descriptive quantitative and qualitative approaches. Quantitative data from student test scores were analyzed to calculate mean, range, and the percentage of students achieving mastery at each cycle, following the formula for classical completeness (≥ 85% of students reaching the KKM benchmark indicates success). Qualitative data from observations and reflections were analyzed thematically to identify patterns of student participation, classroom interaction, and teacher facilitation. Triangulation of these data sources enhanced the credibility of the findings, and member-checking with the teacher further strengthened trustworthiness.

Ethical considerations were addressed throughout the research process. Approval was obtained from the school principal, and informed consent was secured from the classroom teacher and the students' guardians. Anonymity of the students was maintained by using initials in the datasets, and all participants were assured that the data would be used exclusively for academic purposes. The study adhered to the principles of respect, beneficence, and justice in educational research (Crane & Broome, 2017).

RESULTS AND DISCUSSION

Student Learning Outcomes Across Cycles

The results of this classroom action research illustrate a consistent and substantial progression in student learning outcomes across the three iterative cycles of implementation. In Cycle I, the average learning outcome score was 65.9, with only 17 students (51.51%) meeting the mastery threshold. While students expressed enthusiasm toward the *Snowball Throwing* strategy, many demonstrated difficulties

in composing meaningful questions and engaging in peer-to-peer discourse. This indicates that initial exposure to the cooperative learning model required significant teacher scaffolding to guide productive interaction and ensure alignment with instructional objectives.

In Cycle II, improvements were systematically introduced, particularly in providing clearer group instructions and explicit scaffolding for question formulation. These adjustments yielded measurable gains, with the mean score increasing to 70.0, and 23 students (69.69%) meeting mastery criteria. This reflects an 18.19% improvement compared to Cycle I, highlighting the value of cycle-by-cycle refinement in classroom action research. Notably, classroom observations indicated more equitable participation, as students who were initially passive began to contribute to discussions.

By Cycle III, the *Snowball Throwing* strategy was implemented with greater efficiency, and students demonstrated enhanced confidence in both posing and responding to peer-generated questions. The average score rose significantly to 80.0, with 29 students (87.87%) surpassing the mastery benchmark, thereby exceeding the classical completeness standard of 85%. This final cycle confirms that sustained implementation and iterative adjustments fostered not only measurable academic improvement but also a participatory and collaborative classroom culture.

Progression of Mastery Levels

Figure 1 illustrates the progression of mastery levels across the three cycles. The trend demonstrates a consistent upward trajectory, with incremental gains of 18.19% from Cycle I to II and 18.18% from Cycle II to III, suggesting that iterative refinements in the teaching process significantly contributed to learning gains.

Table 1. Summary of Student Achievement Across Cycles

Cycle	Mean Score	Students Mastered	Students Not Mastered	Mastery (%)	Improvement (%)
Cycle I	65.9	17	16	51.51%	–
Cycle II	70.0	23	10	69.69%	+18.19%
Cycle III	80.0	29	4	87.87%	+18.18%

Comparison with Previous Studies

The progressive improvement in student performance validates the effectiveness of active learning approaches. Deslauriers et al. (2019) reported that students in active classrooms outperformed their peers in lecture-based settings, while Theobald et al. (2020) demonstrated that active learning reduces performance gaps, particularly benefiting underachieving students. The current findings resonate with Van Ryzin and Roseth (2019), who emphasized the academic and socio-emotional benefits of structured cooperative learning. Within Indonesia, Kejora (2020) and Ninin Indira et al. (2023) similarly documented improved motivation and achievement through Snowball Throwing, and Bukit et al. (2023) highlighted its role in enhancing curiosity and collaboration. The alignment with these studies underscores the robustness of the strategy, while the present study extends the literature by offering multi-cycle evidence of sustained improvement.

Novel Contributions of the Study

This study offers three principal contributions to the literature on cooperative learning in primary science education. First, it addresses astronomy-related concepts specifically Earth's appearance and celestial motions that are recognized as abstract and conceptually demanding for young learners. Prior research indicates that students frequently hold persistent misconceptions about astronomical phenomena, requiring carefully scaffolded discussion to support conceptual change (Raviv & Dadon, 2021). By demonstrating that the Snowball Throwing strategy can effectively foster understanding even in these challenging domains, the study extends the applicability of cooperative learning beyond familiar and concrete science topics.

Second, the research is situated within an Islamic elementary school in Indonesia, a context rarely represented in international discourse. Although Islamic schools account for a significant proportion of primary education in Indonesia, their unique cultural, curricular, and resource conditions remain largely absent from global comparative research (Nasution, 2017). By

foregrounding this context, the study not only enriches the diversity of evidence in cooperative learning literature but also highlights the potential of adapting such strategies to culturally embedded educational settings.

Third, the study contributes methodological innovation by documenting outcomes across three Classroom Action Research (CAR) cycles. Most prior evaluations of *Snowball Throwing* or similar cooperative learning strategies have been limited to single-cycle or short-duration implementations (Kamarudin & Mat Noor, 2024; Ng & Lo, 2022). By contrast, this study demonstrates the cumulative benefits of iterative instructional refinement, showing how successive adjustments in scaffolding and instruction produce progressively stronger outcomes in student mastery and participation. This cycle-by-cycle evidence offers a richer understanding of the dynamics of pedagogical improvement, providing a model for teachers and researchers interested in sustainable classroom change.

Theoretical and Practical Implications

From a theoretical perspective, the findings reinforce social constructivist learning theory, which emphasizes that knowledge is co-constructed through interaction, dialogue, and negotiation of meaning (Gillies, 2023). By engaging students in collaborative questioning and peer-mediated feedback, Snowball Throwing creates conditions where learners actively articulate, challenge, and refine their ideas processes central to conceptual change in science. Moreover, the results substantiate principles of visible learning (Panadero & Lipnevich, 2022), particularly the value of frequent checks for understanding, formative assessment, and feedback loops that make learning visible to both teachers and students.

From a practical perspective, the study highlights the potential of Snowball Throwing as a low-cost, scalable, and context-sensitive strategy for enhancing science learning in primary schools. Unlike technology-intensive or resource-heavy interventions, this cooperative method requires only paper and classroom organization, making it accessible to schools in resource-constrained environments. Its playful and interactive design aligns with evidence that younger learners benefit from game-like structures and collaborative engagement to sustain attention and motivation. Teachers in this study observed not only improved test scores but also greater willingness among students to participate, pose questions, and engage in peer dialogue skills that are vital for twenty-first-century competencies such as critical thinking, communication, and collaboration.

In addition, the iterative CAR framework underscores the importance of reflective teaching practice, where educators systematically analyze outcomes, adjust instruction, and re-implement refined strategies in subsequent cycles. This recursive process contributes to a culture of continuous professional learning and instructional improvement (Mertler, 2021). By linking instructional refinements to measurable gains in student outcomes, the study illustrates how teacher-led inquiry can serve as a driver of educational quality, particularly in underrepresented contexts such as Islamic elementary schools.

Limitations and Directions for Future Research

Several limitations should be noted. The study involved only one class with 33 students, which constrains the generalizability of the findings. The analysis relied primarily on descriptive statistics, limiting the ability to make broader statistical inferences. Additionally, qualitative data such as student interviews were not collected, which could have provided richer insights into learner experiences. Finally, the study was limited to one science topic, leaving its applicability across other subject areas and grade levels untested. Future research should adopt mixed-methods designs, include larger and more diverse samples, and explore the implementation of Snowball Throwing across different science domains and educational settings. Such extensions would strengthen the external validity and practical relevance of the strategy.

CONCLUSION

This study demonstrated that the Snowball Throwing strategy, when implemented through iterative classroom action research cycles, significantly improved primary students' science learning outcomes on the topic of Earth's appearance and celestial bodies, raising mastery levels from 51.51% in the first cycle to 87.87% in the third cycle and surpassing the classical completeness benchmark. The findings contribute to the growing body of evidence on the effectiveness of active and cooperative learning by highlighting the strategy's applicability to abstract science content and within the underrepresented context of Islamic elementary schools, thus offering both theoretical insights into social constructivist pedagogy and practical guidance for teachers seeking to foster participatory learning environments. Beyond its immediate classroom impact, the study underscores the importance of reflective and iterative teaching practices for achieving sustainable instructional improvement. Nevertheless, the research was limited by its small sample size, reliance on descriptive analysis, and focus on a single topic, suggesting that future studies should involve larger, more diverse cohorts, employ mixed-methods approaches, and explore broader subject areas to further validate and extend the applicability of the Snowball Throwing strategy in enhancing science education.

REFERENCE

Adipat, S., Laksana, K., Busayanon, K., Ausawasowan, A., & Adipat, B. (2021). Engaging students in the learning process with game-based learning: The fundamental concepts. *International Journal of Technology in Education, 4*(3), 542-552. https://doi.org/10.46328/ijte.169

Bergmark, U. (2023). Teachers' professional learning when building a research-based education: Context-specific, collaborative and teacher-driven professional development. *Professional Development in Education, 49*(2), 210-224. https://doi.org/10.1080/19415257.2020.1827011

Bremner, N., Sakata, N., & Cameron, L. (2022). The outcomes of learner-centred pedagogy: A systematic review. *International Journal of Educational Development, 94*, 102649. https://doi.org/10.1016/j.ijedudev.2022.102649

Bukit, S., Ariastika, D., Noviati, Y., & Lubis, Y. (2023). Snowball throwing learning model in growing questioning skills of elementary school students: A review. *Journal Corner of Education, Linguistics, and Literature, 2*(4), 343-351. https://doi.org/10.54012/jcell.v2i4.145

Carless, D., & Boud, D. (2018). The development of student feedback literacy: Enabling uptake of feedback. *Assessment & Evaluation in Higher Education, 43*(8), 1315-1325. https://doi.org/10.1080/02602938.2018.1463354

Chan, K. K. H. (2023). Eliciting and working with student thinking: Preservice science teachers' enactment of core practices when orchestrating collaborative group work. *Journal of Research in Science Teaching, 60*(5), 1014-1052. https://doi.org/10.1002/tea.21823

Chua, Y., Cooray, S., Cortes, J. P. F., Denny, P., Dupuch, S., Garbett, D. L., Nassani, A., Cao, J., Qiao, H., Reis, A., Reis, D., Scholl, P. M., Sridhar, P. K., Suriyaarachchi, H., Taimana, F., Tang, V., Weerasinghe, C., Wen, E., Wu, M., … Nanayakkara, S. (2022). Striving for authentic and sustained technology use in the classroom: Lessons learned from a longitudinal evaluation of a sensor-based science education platform. *International Journal of Human-Computer Interaction, 40*(18), 5073-5086. https://doi.org/10.1080/10447318.2023.2229485

Crane, S., & Broome, M. E. (2017). Understanding ethical issues of research participation from the perspective of participating children and adolescents: A systematic review. *Worldviews on Evidence-Based Nursing, 14*(3), 200-209. https://doi.org/10.1111/wvn.12209

Crawford, R. (2022). Action research as evidence-based practice: Enhancing explicit teaching and learning through critical reflection and collegial peer observation. *Australian Journal of Teacher Education, 47*(12), 53-75. https://doi.org/10.14221/1835-517X.6065

Deslauriers, L., McCarty, L. S., Miller, K., Callaghan, K., & Kestin, G. (2019). Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Sciences, 116*(39), 19251-19257. https://doi.org/10.1073/pnas.1821936116

Education at a Glance 2019. (2019). OECD. https://doi.org/10.1787/f8d7880d-en

Gillies, R. M. (2023). Using cooperative learning to enhance students' learning and engagement during inquiry-based science. *Education Sciences, 13*(12), 1242. https://doi.org/10.3390/educsci13121242

Hardiansyah, F. (2022). Snowball throwing: A method to uplift elementary school students' responsibility on environment. *AL-ISHLAH: Jurnal Pendidikan, 14*(3), 3853-3864. https://doi.org/10.35445/alishlah.v14i3.1966

Irawahyuni, S., Pujiastuti, P., & Nugraheni, A. S. (2021). The effect of snowball throwing cooperative learning model on student learning outcomes. *AL-ISHLAH: Jurnal Pendidikan, 13*(3), 1995-2002. https://doi.org/10.35445/alishlah.v13i3.696

Iwuanyanwu, P. N. (2020). Nature of problem-solving skills for 21st-century STEM learners: What teachers need to know. *Journal of STEM Teacher Education, 54*(1). https://doi.org/10.30707/JSTE55.1/MMDZ8325

Kamarudin, M. Z., & Mat Noor, M. S. A. (2024). What do we know about the selection of action research methodologies in primary science education? - A systematic literature review. *Educational Action Research, 32*(5), 825-847. https://doi.org/10.1080/09650792.2023.2261502

Kejora, M. T. B. (2020). The use of concrete media in science learning in inquiry to improve science process skills for simple machine subject. *MUDARRISA: Jurnal Kajian Pendidikan Islam, 12*(1), 1-17. https://doi.org/10.18326/mdr.v12i1.1-17

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The Action Research Planner.* Springer Singapore. https://doi.org/10.1007/978-981-4560-67-2

Kozanitis, A., & Nenciovici, L. (2023). Effect of active learning versus traditional lecturing on the learning achievement of college students in humanities and social sciences: A meta-analysis. *Higher Education, 86*(6), 1377-1394. https://doi.org/10.1007/s10734-022-00977-8

Li, X., Li, Y., & Wang, W. (2023). Long-lasting conceptual change in science education. *Science & Education, 32*(1), 123-168. https://doi.org/10.1007/s11191-021-00288-x

Manurung, N., Samosir, K., Hia, Y., Mariani, M., Togi, T., & Tambunan, H. (2019). Implementation of snowball throwing type of cooperative learning in calculus course. *International Education Studies, 12*(3), 124. https://doi.org/10.5539/ies.v12n3p124

Mertler, C. A. (2021). *Practical Assessment, Research, and Evaluation Action Research as Teacher Inquiry: A Viable Strategy for Resolving Problems of Practice. Practical Assessment, Research, and Evaluation, 26*, 1-9.

Murtini, S., Murtono, M., & Utaminingsih, S. (2022). The influence of snowball throwing and teams games tournament cooperative learning models on the learning outcomes of elementary school students. *Jurnal Prakarsa Paedagogia, 5*(1). https://doi.org/10.24176/jpp.v5i1.8673

Nasution, W. N. (2017). The effects of learning model and achievement motivation on natural science learning outcomes of students at state Islamic elementary schools in Medan, Indonesia. *Journal of Education and Training, 4*(2), 131. https://doi.org/10.5296/jet.v4i2.11144

Ng, L.-K., & Lo, C.-K. (2022). Enhancing online instructional approaches for sustainable business education in the current and post-pandemic era: An action research study of student engagement. *Education Sciences, 13*(1), 42. https://doi.org/10.3390/educsci13010042

Ninin Indira, Vivi Ari Adianti, & Siti Masitho Desinta Rizkya. (2023). Efforts to improve science learning outcomes through the STAD type cooperative model. *Journal of Action Research in Education, 1*(2), 85-98. https://doi.org/10.52620/jare.v1i2.66

Panadero, E., & Lipnevich, A. A. (2022). A review of feedback models and typologies: Towards an integrative model of feedback elements. *Educational Research Review, 35*, 100416. https://doi.org/10.1016/j.edurev.2021.100416

Popova, A., Evans, D. K., Breeding, M. E., & Arancibia, V. (2022). Teacher professional development around the world: The gap between evidence and practice. *The World Bank Research Observer, 37*(1), 107-136. https://doi.org/10.1093/wbro/lkab006

Raviv, A., & Dadon, M. (2021). Teaching astronomy in kindergarten: Children's perceptions and projects. *Athens Journal of Education, 8*(3), 305-328. https://doi.org/10.30958/aje.8-3-4

Rivera, E. S., & Garden, C. L. P. (2021). Gamification for student engagement: A framework. *Journal of Further and Higher Education, 45*(7), 999-1012. https://doi.org/10.1080/0309877X.2021.1875201

Saini, M., Sengupta, E., Singh, M., Singh, H., & Singh, J. (2023). Sustainable development goal for quality education (SDG 4): A study on SDG 4 to extract the pattern of association among the indicators of SDG 4 employing a genetic algorithm. *Education and Information Technologies, 28*(2), 2031-2069. https://doi.org/10.1007/s10639-022-11265-4

Sandrone, S., Scott, G., Anderson, W. J., & Musunuru, K. (2021). Active learning-based STEM education for in-person and online learning. *Cell, 184*(6), 1409-1414. https://doi.org/10.1016/j.cell.2021.01.045

Santosa, W. H., & Sudirman, A. (2023). Factors influencing the implementation of cooperative learning: Elementary school teacher education department students' perspectives. *Edunesia: Jurnal Ilmiah Pendidikan, 4*(3), 1031-1048. https://doi.org/10.51276/edu.v4i3.501

Soomro, R. B. K., Soomro, A. B., & Memon, I. (2025). Inquiry-based science teaching and its impact on critical thinking and problem-solving skills: A meta-analysis of STEM education. https://doi.org/10.21203/rs.3.rs-6365963/v1

Theobald, E. J., Hill, M. J., Tran, E., Agrawal, S., Arroyo, E. N., Behling, S., Chambwe, N., Cintrón, D. L., Cooper, J. D., Dunster, G., Grummer, J. A., Hennessey, K., Hsiao, J., Iranon, N., Jones, L., Jordt, H., Keller, M., Lacey, M. E., Littlefield, C. E., … Freeman, S. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences, 117*(12), 6476-6483. https://doi.org/10.1073/pnas.1916903117

Urdanivia Alarcon, D. A., Talavera-Mendoza, F., Rucano Paucar, F. H., Cayani Caceres, K. S., & Machaca Viza, R. (2023). Science and inquiry-based teaching and learning: A systematic review. *Frontiers in Education, 8.* https://doi.org/10.3389/feduc.2023.1170487

Van Ryzin, M. J., & Roseth, C. J. (2019). Effects of cooperative learning on peer relations, empathy, and bullying in middle school. *Aggressive Behavior, 45*(6), 643-651. https://doi.org/10.1002/ab.21858

Von Korff, J., Archibeque, B., Gomez, K. A., Heckendorf, T., McKagan, S. B., Sayre, E. C., Schenk, E. W., Shepherd, C., & Sorell, L. (2016). Secondary analysis of teaching methods in introductory physics: A 50 k-student study. *American Journal of Physics, 84*(12), 969-974. https://doi.org/10.1119/1.4964354

Wakeman, S. Y., Ahlgrim-Delzell, L., Gezer, T., Pennington, R., & Saunders, A. (2022). Using action research to develop a professional development and coaching package for educators within inclusive reading instruction. *Disabilities, 2*(4), 641-661. https://doi.org/10.3390/disabilities2040046

William, K., Siahaan, A., Haloho, U. N., Pulina, M., Rajagukguk, A., Sihombing, N. R., & Harianja, R. N. (2020). The effect of the snowball throwing learning model to the science learning outcomes of grade 5 Indonesian student's. *International Journal of Education and Humanities (IJEH), 1*(1), 34-42. https://doi.org/10.58557/ijeh.v1i1.4