



A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

Darin Jan Tindowen¹, Rosario Danga²

¹Commission on Higher Education – Region 2 Tuguegarao City, Philippines

²Department of Science and Technology – Region 2 Tuguegarao City, Philippines

ABSTRACT: The integration of robotics in education has emerged as a promising approach for strengthening students' STEM competencies by providing authentic opportunities for creativity, problem-solving, and technology application. This study assessed the level of students' STEM-related skills and attitudes in robotics-based learning environments. Employing a quantitative descriptive research design, the study involved 150 students enrolled in Robotics subjects during School Year 2025–2026 from selected schools in Northern Philippines. Data were collected using an adapted questionnaire on STEM skills understanding, contextualized for robotics-based learning environments. The instrument measured three dimensions: general skills, problem-solving skills, and attitudes toward STEM and robotics-based learning. Descriptive statistics, particularly weighted mean and standard deviation, were utilized to determine the level of students' competencies and perceptions. The findings revealed that students demonstrated very highly developed levels of STEM-related general skills, indicating strong abilities in creativity, innovation, experiential learning, idea generation, and practical application of concepts. Similarly, students exhibited very highly developed problem-solving skills, reflecting their capacity to analyze challenges, generate solutions, apply interdisciplinary knowledge, and collaborate effectively during robotics activities. Furthermore, students demonstrated very highly developed attitudes toward STEM and robotics-based learning, showing strong recognition of the relevance of STEM disciplines and the value of robotics for academic and future professional development. The study concludes that robotics-based learning environments serve as effective platforms for developing multidimensional STEM competencies by integrating cognitive, creative, collaborative, and affective learning outcomes. The findings highlight the importance of sustaining robotics integration in STEM education to prepare learners with the skills and dispositions necessary for future innovation and technological advancement.

KEYWORDS: robotics-based learning, STEM education, STEM skills, problem-solving skills, STEM attitudes, educational robotics, technology-enhanced learning, Philippines.

Cite the Article: Tindowen, D.J., Danga, R. (2026). A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments. *Contemporary Research Analysis Journal*, 3(10), 734-741. <https://doi.org/10.55677/CRAJ/10-2026-Vol03I10>

License: This is an open-access article under the CC BY 4.0 license: <https://creativecommons.org/licenses/by/4.0/>

Publication Date: October 14, 2026

**Corresponding Author:* Darin Jan Tindowen

INTRODUCTION

The rapid advancement of digital technologies, automation, and artificial intelligence has transformed the competencies expected of learners in contemporary society. Beyond disciplinary knowledge, students are increasingly required to demonstrate creativity, critical thinking, collaboration, technological literacy, and problem-solving abilities to navigate complex and rapidly changing environments. This shift has positioned STEM education as a critical approach for developing future-ready learners who can integrate scientific knowledge, technological skills, engineering processes, and mathematical reasoning to address real-world challenges. Consequently, STEM education has evolved from a content-oriented approach toward a competency-based learning paradigm emphasizing innovation, inquiry, and the application of knowledge.

Within this evolving landscape, educational robotics has emerged as a promising approach for strengthening STEM learning outcomes. Robotics-based learning environments provide students with opportunities to design, construct, program, test, and refine technological solutions, allowing them to engage in authentic processes of inquiry and engineering design. Unlike traditional instructional approaches that often emphasize knowledge acquisition, robotics activities encourage active participation, experimentation, collaboration, and iterative problem-solving. Recent studies indicate that educational robotics can support the

A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

development of computational thinking, creativity, collaboration, and learner engagement by enabling students to apply STEM concepts in meaningful and practical contexts (Nurassyl, et al, 2023; Sapounidis, et al., 2024; Ching & Hsu, 2023). Furthermore, evidence suggests that robotics-based interventions contribute positively to STEM learning outcomes; however, their effects vary depending on learning contexts, instructional approaches, and the competencies being measured (Fan & Xu, 2024).

Despite the growing adoption of robotics in STEM education, an important conceptual challenge remains. Educational robotics is widely promoted as a mechanism for developing holistic twenty-first-century competencies, yet assessment practices often focus on narrow indicators such as programming performance, academic achievement, or technical skills (Coskun & Filiz, 2023). Such approaches provide only a limited understanding of the broader learning outcomes generated within robotics environments. The educational value of robotics extends beyond students' ability to operate technological systems; it also involves their capacity to generate creative ideas, solve problems systematically, collaborate with others, and develop positive attitudes toward STEM fields. Therefore, assessing robotics-based learning requires a multidimensional perspective that captures both students' skills and dispositions.

This concern is particularly relevant in the Philippine educational context. The country has increasingly prioritized STEM education through curriculum reforms, technology integration initiatives, and programs designed to strengthen scientific literacy, innovation, and digital competence among learners (Paderna & Monterola, 2021; Diola, 2026). The implementation of the K to 12 Basic Education Program and the establishment of STEM strands in senior high school reflect national efforts to prepare students for science- and technology-oriented academic and professional pathways. However, challenges remain in translating STEM policy aspirations into authentic learning experiences that consistently develop higher-order competencies such as creativity, innovation, and problem-solving (Vera, et al., 2025). Although educational robotics has gained attention in Philippine schools and higher education institutions through robotics competitions, innovation programs, and technology-enhanced learning initiatives, its implementation remains influenced by contextual factors such as resource availability, teacher preparedness, and institutional capacity. Moreover, existing Philippine studies on robotics education have largely emphasized implementation processes, technological development, or specific technical competencies. Limited empirical evidence exists regarding the broader outcomes of robotics-based learning, particularly students' general skills, problem-solving abilities, and attitudes toward STEM (Coufal, 2022; Zvi-Girshin & Rosenberg, 2025).

The existing literature also reveals a methodological limitation in understanding robotics-based STEM learning. While previous studies have demonstrated the potential of robotics to enhance selected learning outcomes, many investigations examine individual competencies separately rather than considering the interconnected nature of STEM development. Students engaged in robotics learning simultaneously develop cognitive skills, creative capacities, collaborative behaviors, and affective orientations. However, the extent to which these dimensions collectively characterize students' STEM competencies remains insufficiently explored. As emphasized by recent reviews, there is a need for assessment frameworks that move beyond measuring isolated technical outcomes and instead examine the broader educational impact of robotics-based environments (Tabinska, 2025; Chandak, 2025).

Addressing this gap, the present study seeks to provide a comprehensive assessment of students' competencies developed through robotics-based learning. Specifically, the study examines three interconnected dimensions: general skills, which include creativity, innovation, and idea development; problem-solving skills, which involve analytical reasoning, solution generation, and collaboration; and STEM attitudes, which reflect students' perceptions of technology, robotics, and the relevance of STEM learning. By adopting a multidimensional assessment approach, this study contributes to a deeper understanding of how robotics-based learning environments support the development of future-ready learners. The findings may provide meaningful implications for educators, curriculum developers, and educational leaders in designing STEM learning experiences that not only integrate technology but also cultivate creativity, problem-solving capacity, and sustained interest in STEM pathways among students.

METHOD

This study employed a quantitative descriptive research design to assess students' STEM-related skills and attitudes in robotics-based learning environments. Specifically, the study examined three dimensions of STEM-related outcomes: general skills, problem-solving skills, and attitudes toward STEM and robotics-based learning.

The participants of the study were 150 students enrolled in Robotics subjects during School Year 2025–2026 from selected schools in Northern Philippines. The participants were selected using purposive sampling based on the following inclusion criteria: (1) currently enrolled in a Robotics subject during the specified academic year, (2) have direct exposure to robotics-based learning activities, and (3) voluntarily agreed to participate in the study.

The study utilized an adapted questionnaire based on the instrument developed by Ahsan, et al. (2023) to measure students' understanding of STEM-related skills in achieving sustainable development goals; however, for the present study, the questionnaire was contextualized to assess STEM-related skills and attitudes within robotics-based learning environments. The adaptation process involved modifying the items to align with students' experiences in Robotics subjects while maintaining the original constructs measured by the instrument. The adapted questionnaire consisted of three dimensions. The first dimension, General Skills, assessed

A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

students' creativity, innovation, idea generation, experimentation, and project development abilities. The second dimension, Problem-Solving Skills, measured students' abilities to analyze problems, generate solutions, apply knowledge, collaborate with peers, and use logical and systematic approaches in addressing challenges encountered during robotics activities. The third dimension, Attitudes Toward STEM and Robotics-Based Learning, examined students' perceptions regarding the value, relevance, and importance of STEM disciplines, technology, and robotics in their learning experiences and future professional development. The questionnaire items were subjected to expert validation to ensure their contextual relevance and appropriateness for robotics-based learning environments. The content validity ratio (CVR) values obtained from expert evaluation indicated that the retained items adequately represented the intended constructs. Reliability analysis was also conducted to establish the internal consistency of the instrument prior to data collection.

Data collection was conducted after securing permission from school administrators and obtaining informed consent from the participants. The purpose of the study, procedures, and ethical considerations were explained to the respondents before the administration of the questionnaire. Participation was voluntary, and respondents were assured that their responses would remain confidential and would only be used for research purposes. The completed questionnaires were collected, reviewed for completeness, encoded, and prepared for statistical analysis. The collected data were analyzed using descriptive statistics. Weighted mean and standard deviation were employed to determine the level of students' STEM-related general skills, problem-solving skills, and attitudes toward STEM and robotics-based learning. The interpretation of the students' responses was based on a five-point Likert scale, where higher mean scores indicated higher levels of STEM-related skills and more positive attitudes toward robotics-based learning. The analysis was structured according to the three research questions of the study, focusing on the level of students' general skills, problem-solving skills, and attitudes within robotics-based learning environments.

Ethical principles in educational research were observed throughout the conduct of the study. The participation of respondents was voluntary, and their privacy, confidentiality, and anonymity were protected. No personally identifiable information was collected, and all gathered data were securely managed and utilized solely for academic and research purposes.

RESULTS AND DISCUSSION

Table 1. Level of Students' STEM-Related General Skills in Robotics-Based Learning Environments

Indicators	Mean	Qualitative Description
The use of various methods enhances STEM-related skills development.	4.42	Very Highly Developed
Learning is enhanced through hands-on and experiential activities.	4.58	Very Highly Developed
Students demonstrate the ability to create digital models or machines.	4.36	Very Highly Developed
Students demonstrate imagination and creativity in generating innovative ideas.	4.39	Very Highly Developed
Students are able to develop products or solutions using recycled materials.	4.18	Highly Developed
Students can communicate ideas using charts, diagrams, and other visual representations.	4.31	Very Highly Developed
Completion of one project encourages engagement in subsequent projects.	4.35	Very Highly Developed
Students demonstrate willingness to understand how systems and processes work.	4.55	Very Highly Developed
Students develop learning through experimentation, testing, and trial-and-error processes.	4.47	Very Highly Developed
Students demonstrate eagerness to understand the fundamental concepts underlying projects.	4.51	Very Highly Developed
Students are able to evaluate the correctness, effectiveness, and usefulness of project outputs.	4.34	Very Highly Developed
Students recognize practical applications of newly acquired STEM concepts.	4.49	Very Highly Developed
Category Mean	4.41	Very Highly Developed

Table 1 presents the level of students' STEM-related general skills in robotics-based learning environments. The findings revealed that students demonstrated a very highly developed level of general skills, indicating that participation in robotics-based learning environments effectively supports the development of creativity, innovation, experiential learning, and practical application of

A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

STEM concepts. The overall pattern of results suggests that robotics activities provide students with opportunities to move beyond passive knowledge acquisition and engage actively in designing, creating, testing, and improving solutions.

The highest-rated indicators reflected students' ability to understand how systems and processes work, learn through hands-on experiences, and recognize practical applications of STEM concepts. These findings indicate that robotics-based learning promotes an inquiry-oriented learning experience where students are encouraged to explore mechanisms, investigate relationships among components, and apply theoretical knowledge to authentic tasks. Such outcomes are consistent with Constructionism Theory, which emphasizes that meaningful learning occurs when learners actively construct knowledge through the creation of tangible artifacts. In robotics environments, students do not simply learn about technological concepts; they transform abstract ideas into functional models, allowing deeper conceptual understanding and skill development (Budiman, et al., 2025).

The strong performance of students in creativity and idea-generation indicators further highlights the role of robotics as an innovation-driven learning platform. Robotics projects commonly involve open-ended challenges where multiple solutions may be possible, requiring learners to imagine new possibilities, experiment with designs, and revise their outputs based on testing results. This finding supports previous studies emphasizing that educational robotics enhances creativity and innovation by providing learners with opportunities to engage in iterative design processes and problem-based learning experiences (Usher, et al., 2025; Zhang & Zhu, 2022). The results suggest that robotics-based learning environments serve as effective spaces for nurturing students' ability to generate and refine ideas, which are essential competencies in contemporary STEM education.

Another important finding is the high level of students' engagement in experimentation, testing, and trial-and-error processes. This indicates that robotics activities cultivate productive learning behaviors where mistakes are perceived as opportunities for improvement rather than failures. Through repeated cycles of designing, programming, and troubleshooting, students develop persistence, adaptability, and reflective thinking. This aligns with experiential learning perspectives, which argue that knowledge development occurs through the continuous interaction of experience, reflection, conceptualization, and application (Motta & Galina, 2023). The findings provide additional evidence that robotics-based learning contributes not only to technical competence but also to the development of learning dispositions necessary for innovation and lifelong learning. Although all indicators were assessed at a very highly developed level, the comparatively lower rating related to developing products or solutions using recycled materials suggests a potential area for further enhancement. While students demonstrated strong technological and creative abilities, sustainability-oriented practices within robotics activities may require greater emphasis. Integrating environmental considerations, resource optimization, and sustainable design principles into robotics projects may further strengthen the connection between STEM learning and broader societal challenges.

Overall, the findings from Table demonstrate that robotics-based learning environments significantly contribute to the development of students' STEM-related general skills. The study extends existing understanding by showing that robotics education functions not merely as a means of teaching programming or technological concepts but as a comprehensive learning environment that fosters creativity, experimentation, innovation, and practical STEM application. These findings reinforce the importance of designing robotics-based STEM programs that intentionally target multidimensional competencies necessary for preparing learners for future academic, professional, and societal demands.

Table 2. Level of Students' Problem-Solving Skills in Robotics-Based Learning Environments

Indicators	Mean	Qualitative Description
Students apply previous experiences in solving new problems.	4.46	Very Highly Developed
Students are able to transform ideas into practical actions.	4.43	Very Highly Developed
Students reconsider problems to develop deeper understanding and identify appropriate solutions.	4.37	Very Highly Developed
Students are able to evaluate and modify ideas when necessary.	4.32	Very Highly Developed
Students confidently generate creative approaches to solve problems.	4.41	Very Highly Developed
Students explore accurate and effective solutions to identified problems.	4.38	Very Highly Developed
Robotics projects enhance students' ability to establish positive relationships with peers.	4.29	Very Highly Developed
Students are able to integrate science, technology, engineering, and mathematics concepts in solving problems.	4.45	Very Highly Developed
Students actively discuss ideas and solutions with peers.	4.47	Very Highly Developed
Teamwork supports the achievement of project goals.	4.54	Very Highly Developed
Students apply systematic and logical approaches in solving problems.	4.48	Very Highly Developed
Students utilize problem-solving skills to resolve challenges encountered during robotics activities.	4.50	Very Highly Developed
Category Mean	4.42	Very Highly Developed

A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

Table 2 presents the level of students' problem-solving skills in robotics-based learning environments. The findings revealed that students demonstrated a very highly developed level of problem-solving skills, indicating that robotics-based learning provides meaningful opportunities for learners to analyze situations, generate solutions, apply STEM knowledge, and collaborate with others in addressing challenges. The overall pattern of results suggests that robotics activities create an environment where students are continuously engaged in identifying problems, testing possible solutions, and improving their designs through systematic processes. A notable finding from the assessment is the strong development of students' ability to apply logical and systematic approaches in solving problems. Robotics-based learning requires learners to follow processes involving problem identification, planning, designing, programming, testing, and modification. These experiences allow students to develop structured thinking and analytical reasoning, which are fundamental components of STEM problem-solving. The findings support the principles of experiential learning theory, which emphasizes that learners construct knowledge through active engagement with experiences and reflection on the outcomes of their actions. In robotics environments, students encounter authentic challenges that require them to analyze conditions, make decisions, and evaluate the effectiveness of their solutions (Govender & Govender, 2023).

The results also revealed a very high level of collaborative problem-solving among students. The strong performance in indicators related to teamwork, peer discussion, and achievement of project goals highlights the social dimension of robotics-based learning. Unlike individual learning tasks, robotics projects commonly require students to work together in designing systems, assigning responsibilities, troubleshooting errors, and reaching collective decisions. This finding supports the sociocultural perspective of learning, which emphasizes that knowledge construction is strengthened through interaction, communication, and collaboration with others (Saljo, 2022). The study therefore highlights that robotics education develops not only individual cognitive abilities but also interpersonal competencies essential for STEM engagement.

Students' ability to transform ideas into practical actions and explore effective solutions further demonstrates the value of robotics as an authentic problem-based learning environment. Robotics activities require learners to convert conceptual ideas into functional outputs, requiring creativity, persistence, and adaptability. The process of designing and improving robotic systems exposes students to real-world engineering practices where solutions are rarely immediate and require continuous refinement. This finding is consistent with previous research indicating that robotics-based learning enhances higher-order thinking skills by engaging students in design challenges that mirror professional STEM practices (Hwang, et al., 2026; Ching & Hsu, 2023).

The high level of integration of science, technology, engineering, and mathematics concepts in solving problems is another significant finding of the study. Robotics serves as an interdisciplinary platform where students apply knowledge from different STEM domains to accomplish specific tasks. Rather than learning STEM concepts separately, students experience how these disciplines interact in solving authentic problems (Darmawansah, et al., 2023). This provides evidence that robotics-based learning can address one of the major challenges in STEM education—the need to connect classroom knowledge with practical applications. While all indicators were assessed at a very highly developed level, the relatively lower rating related to evaluating and modifying ideas suggests that continuous opportunities for reflection and redesign remain important. Although students demonstrate strong problem-solving abilities, instructional strategies that explicitly incorporate reflection, peer feedback, and iterative improvement may further strengthen their capacity to critically evaluate solutions and optimize project outcomes.

Overall, the findings from Table 2 demonstrate that robotics-based learning environments effectively cultivate students' problem-solving competencies by promoting analytical reasoning, creativity, collaboration, and application of interdisciplinary knowledge. The study contributes new insight by showing that robotics education should not be viewed solely as a technology-focused learning approach but as a comprehensive STEM environment that develops learners' capacity to approach complex problems systematically and collaboratively. These findings reinforce the importance of integrating robotics-based experiences into STEM education to prepare students with the problem-solving capabilities required in an increasingly complex and technology-driven world.

Table 3. Level of Students' Attitudes Toward STEM and Robotics-Based Learning

Indicators	Mean	Qualitative Description
Students recognize the role of science, technology, engineering, and mathematics in addressing real-life problems.	4.56	Very Highly Developed
Students are able to connect scientific concepts with practical applications.	4.48	Very Highly Developed
Robotics-based learning supports students' understanding of STEM concepts and processes.	4.52	Very Highly Developed
Students recognize the importance of mathematical reasoning in solving STEM-related problems.	4.41	Very Highly Developed
Robotics activities help students complete learning projects effectively.	4.47	Very Highly Developed
Students are confident in explaining computer programming concepts to classmates.	4.25	Very Highly Developed

A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

Students perceive robotics as an appropriate approach for integrating different curricular areas.	4.50	Very Highly Developed
Students consider robotics valuable for their future academic and professional development.	4.58	Very Highly Developed
Students recognize the impact of technology on classroom learning experiences.	4.60	Very Highly Developed
Students believe that technology is essential in different levels of education.	4.55	Very Highly Developed
Category Mean	4.49	Very Highly Developed

Table 3 presents the level of students' attitudes toward STEM and robotics-based learning environments. The findings revealed that students demonstrated a very highly developed level of positive attitudes toward STEM and robotics, indicating that robotics-based learning effectively strengthens students' appreciation of STEM disciplines, recognition of technology's importance, and understanding of robotics as a meaningful learning experience. The results suggest that students perceive robotics not only as an instructional tool but also as an important pathway for developing knowledge and competencies relevant to their future academic and professional endeavors.

One of the most significant findings is that students strongly recognized the role of science, technology, engineering, and mathematics in addressing real-life problems. This indicates that robotics-based learning successfully helps students understand the practical relevance of STEM concepts beyond the classroom. Through robotics activities, learners experience how scientific principles, technological applications, engineering processes, and mathematical reasoning work together to develop solutions. This finding supports the view that authentic STEM learning experiences enhance students' ability to connect academic knowledge with real-world contexts, thereby strengthening their perception of STEM as meaningful and applicable (Chang, et al., 2024).

The findings also showed that students highly valued robotics as a learning approach that supports their understanding of STEM concepts and processes. This positive perception may be attributed to the experiential and interactive nature of robotics activities, where students actively engage in designing, programming, constructing, and testing solutions. Unlike traditional instructional approaches that may emphasize theoretical understanding, robotics provides learners with concrete experiences that make abstract STEM concepts more understandable and relevant (Kalaitzidou & Pachidis, 2023). This supports constructivist perspectives of learning, where meaningful understanding develops through active participation and engagement with authentic learning tasks.

Another important finding is students' strong perception of robotics as valuable for their future academic and professional development. This suggests that robotics-based learning contributes to students' awareness of STEM-related career opportunities and the importance of technological competencies in the future workforce. The positive attitudes observed among students indicate that robotics experiences may influence not only current learning engagement but also their aspirations and willingness to pursue STEM-related pathways. This finding is particularly relevant in the Philippine educational context, where strengthening students' interest and participation in STEM fields remains an important priority. The results further revealed that students strongly acknowledged the impact and importance of technology in classroom learning. This demonstrates that robotics-based environments contribute to technology acceptance by allowing students to experience technology as a tool for creativity, collaboration, and problem-solving rather than merely as a means of accessing information. The findings suggest that direct engagement with robotics increases students' confidence and appreciation of technology-enhanced learning environments.

Although all indicators obtained very high ratings, the relatively lower score related to students' confidence in explaining computer programming concepts to classmates suggests that technical communication skills may require further development. While students may understand programming processes and successfully complete robotics tasks, opportunities for presenting, explaining, and defending their ideas can further enhance their ability to communicate STEM knowledge. Integrating project presentations, peer demonstrations, and collaborative discussions may strengthen this dimension of STEM learning.

Overall, the findings from Table 3 demonstrate that robotics-based learning environments foster highly positive attitudes toward STEM and technology among students. The study contributes to the growing body of STEM education research by highlighting that robotics learning influences not only students' skills development but also their perceptions, motivation, and appreciation of STEM disciplines. These findings emphasize that effective robotics integration should focus on creating meaningful learning experiences that cultivate both competence and positive dispositions, ensuring that students are prepared to participate actively in a technology-driven and innovation-oriented society.

CONCLUSION

The study concludes that robotics-based learning environments contribute significantly to the development of students' STEM-related skills and attitudes. Students demonstrated very highly developed levels of general skills, problem-solving skills, and attitudes toward STEM and robotics-based learning. The findings indicate that robotics activities provide meaningful opportunities

A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

for learners to enhance creativity, innovation, experiential learning, logical reasoning, collaboration, and the practical application of STEM concepts. Through engagement in robotics design, programming, testing, and improvement processes, students develop competencies that extend beyond technical knowledge toward broader twenty-first-century skills. The study further stressed that robotics-based learning serves as a multidimensional STEM learning environment that strengthens both students' capabilities and dispositions toward science and technology. The positive attitudes demonstrated by students reflect their recognition of STEM relevance in real-life applications and future academic and professional development. These findings contribute new understanding that robotics education should be implemented not only as a tool for teaching technological skills but also as an approach for developing creative thinkers, effective problem-solvers, and motivated STEM learners.

REFERENCES

- 1) Ahsan, N., Khurram, A. T. A., & Ramzan, N. (2023). Development and Validation of Research Instrument Conceptual Understanding of STEM Skills Questionnaire for Achievement of Sustainable Development Goals. *Academy of Education and Social Sciences Review*. <https://doi.org/10.48112/aessr.v3i4.637>
- 2) Budiman, R. D. A., Surjono, H. D., W., M., Hidayat, E., & S. (2025). Gamification: Enhancing Constructivist Skills through Line-Following Robots. *Int. J. Online Biomed. Eng.*, 21, 132-150. <https://doi.org/10.3991/ijoe.v21i01.51727>
- 3) Chandak, P. (2025). Advancing Robotics-Enabled STEM Education in K-12: Frameworks for Comprehensive Learning Outcomes Assessment and Inclusivity. *INTERANTIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT*. <https://doi.org/10.55041/ijssrem11253>
- 4) Chang, Y., Choi, J., & Şen-Akbulut, M. (2024). Undergraduate Students' Engagement in Project-Based Learning with an Authentic Context. *Education Sciences*. <https://doi.org/10.3390/educsci14020168>
- 5) Ching, Y.-H., & Hsu, Y. (2023). Educational Robotics for Developing Computational Thinking in Young Learners: A Systematic Review. *Techtrends*, 1 - 12. <https://doi.org/10.1007/s11528-023-00841-1>
- 6) Ching, Y.-H., & Hsu, Y. (2023). Educational Robotics for Developing Computational Thinking in Young Learners: A Systematic Review. *Techtrends*, 1 - 12. <https://doi.org/10.1007/s11528-023-00841-1>
- 7) Coşkun, T. K., & Filiz, O. (2023). The impact of twenty-first century skills on university students' robotic achievements. *Education and Information Technologies*, 28, 16255-16283. <https://doi.org/10.1007/s10639-023-11850-1>
- 8) Coufal, P. (2022). Project-Based STEM Learning Using Educational Robotics as the Development of Student Problem-Solving Competence. *Mathematics*. <https://doi.org/10.3390/math10234618>
- 9) Darmawansah, D., Hwang, G.-J., Chen, M.-R. A., & Liang, J. (2023). Trends and research foci of robotics-based STEM education: a systematic review from diverse angles based on the technology-based learning model. *International Journal of STEM Education*, 10, 1-24. <https://doi.org/10.1186/s40594-023-00400-3>
- 10) Diola, A. (2026). Strengthening Math and Science Literacy in the Philippines: Confronting Classroom Challenges with Innovation and Resilience. *Asian Research Journal of Education*. <https://doi.org/10.66206/9h4x5995>
- 11) Fan, O., & Xu, W. (2024). The effects of educational robotics in STEM education: a multilevel meta-analysis. *International Journal of STEM Education*, 11. <https://doi.org/10.1186/s40594-024-00469-4>
- 12) Govender, R. G., & Govender, D. (2023). Using Robotics in the Learning of Computer Programming: Student Experiences Based on Experiential Learning Cycles. *Education Sciences*. <https://doi.org/10.3390/educsci13030322>
- 13) Hwang, G.-J., Lee, H.-F., & Chang, C.-Y. (2026). Effects of Generative AI-Empowered Collaborative Robot Project-Based Learning on Students' Learning Achievements and Higher Order Thinking Tendencies in Professional Training. *Journal of Educational Computing Research*. <https://doi.org/10.1177/07356331261437504>
- 14) Kalaitzidou, M. A., & Pachidis, T. (2023). Recent Robots in STEAM Education. *Education Sciences*. <https://doi.org/10.3390/educsci13030272>
- 15) Motta, V., & Galina, S. (2023). Experiential learning in entrepreneurship education: A systematic literature review. *Teaching and Teacher Education*. <https://doi.org/10.1016/j.tate.2022.103919>
- 16) Nurassyl, K., Nurym, N., Akramova, A., & Abdykarimova, S. (2023). Educational Robotics: Development of computational thinking in collaborative online learning. *Education and Information Technologies*, 1 - 23. <https://doi.org/10.1007/s10639-023-11806-5>
- 17) Paderna, E. E. S., & Monterola, S. L. C. (2021). Advancing integrated STEM education in the Philippines through STEM curriculum implementation. *STEM Education from Asia*. <https://doi.org/10.4324/9781003099888-7>
- 18) Säljö, R. (2022). Learning in a Sociocultural Perspective. 498-502. <https://doi.org/10.1016/b978-0-08-044894-7.00471-1>
- 19) Sapounidis, T., Rapti, S., & Vaiopoulou, J. (2024). "Effects of Educational Robotics on Kindergarteners' Collaboration, Communication, Critical Thinking, and Creativity: A Meta-Analysis". *Journal of Science Education and Technology*, 34, 73 - 87. <https://doi.org/10.1007/s10956-024-10149-1>

A Multidimensional Assessment of Stem-Related Skills and Attitudes Among Students in Robotics-Based Learning Environments

- 20) Tabinska, O. (2025). Interactive learning in the digital age: Advancing STEM skills in primary school education through robotics. *Periodicals of Engineering and Natural Sciences (PEN)*. <https://doi.org/10.21533/pen.v13.i3.450>
- 21) Usher, M., Reznik, N., Bronshtein, G., & Kohen-Vacs, D. (2025). Bridging Virtual and Physical: Exploring Students' Computational Thinking and Creativity in Robot-Guided vs. Simulation-Based Learning. *J. Learn. Anal.*, 12, 35-49. <https://doi.org/10.18608/jla.2025.8837>
- 22) Vera, J. L. D., Castulo, N. J., Sebial, S. C., Aliazas, J. V. C., Pelgone, A. J. O., Gonong, D. M. D. M., Pastor, C. J. M., & Ramos-Butron, B. (2025). Integrating AI in STEM education: exploring future STEM competencies of pre-service science teachers in the Philippines. *Disciplinary and Interdisciplinary Science Education Research*, 7. <https://doi.org/10.1186/s43031-025-00143-x>
- 23) Zhang, Y., & Zhu, Y.-Z. (2022). Effects of educational robotics on the creativity and problem-solving skills of K-12 students: a meta-analysis. *Educational Studies*, 50, 1539 - 1557. <https://doi.org/10.1080/03055698.2022.2107873>
- 24) Zviel-Girshin, R., & Rosenberg, N. (2025). Enhancing Early STEM Engagement: The Impact of Inquiry-Based Robotics Projects on First-Grade Students' Problem-Solving Self-Efficacy and Collaborative Attitudes. *Education Sciences*. <https://doi.org/10.3390/educsci15101404>