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THE VALIDITY AND EFFECTIVENESS OF THE INSTRUCTIONAL MATERIALS IN ROBOTICS OF GRADE 7

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ABSTRACT

This study evaluated the validity and effectiveness of teacher-developed instructional materials (IMs) in Robotics for Grade 7, emphasizing their impact on students' knowledge, skills, and attitudes (KSA). The rationale stemmed from the increasing need for contextualized STEM learning tools aligned with the Most Essential Learning Competencies (MELCs) in the K to 12 curriculums. The study aimed to describe the content, instructional, and technical features of the IMs, assess their validity, measure their effectiveness, and recommend enhancements to Robotics instruction. A mixed-methods research design was employed, combining developmental and descriptive approaches with a quasi-experimental pretest-posttest setup. Data were collected through expert evaluations, KSA-based assessments, attitude surveys, and teacher interviews. The instructional materials were validated using an adapted DepEd LRMDS evaluation tool, yielding Content Validity Index (CVI) scores above 0.80, indicating high quality. Students' mean test scores increased from 36.3% to 90.3%, with Z-tests confirming significant knowledge gains. Performance tasks showed high proficiency in programming, assembly, and collaboration, while attitude surveys revealed increased interest and confidence in Robotics. Theories applied include Constructivist Learning, Active Learning, Gamification, and Innovation Theory, all of which shaped the student-centered, inquiry-driven design of the IMs. The study concludes that teacher-created materials, when systematically developed and evaluated, can effectively enhance learning in emerging STEM areas like Robotics, supporting inclusive and localized education practices. It recommends continuous teacher training, expanded access to Robotics tools, and further research into long-term and scalable applications.

Keywords: *Robotics Education, Instructional Materials, STEM, Constructivist Learning, Content Validity Index, 7E Model, Gamification, Mixed Methods, Grade 7, DepEd LRMDS*

Introduction

Integrating robotics into the classroom has proven to be a groundbreaking strategy that redefines conventional teaching practices while boosting student involvement. This innovative approach not only sparks learners' curiosity but also fosters vital 21st-century competencies such as critical thinking, problem-solving, and teamwork. Contemporary research emphasizes the beneficial effects of robotics on students' academic performance, especially within STEM (Science, Technology, Engineering, and Mathematics) areas.

A study published in 2023 demonstrated that incorporating educational robots into the curriculum significantly improved students' understanding of robotics design and coding skills, as well as increased their aspirations toward computing careers. This aligns with the findings of another meta-analysis, which reported that teaching methods utilizing educational robots can enhance learning outcomes by a moderate but significant effect size.

The success of robotics education greatly depends on the caliber of the instructional materials utilized. Teacher-crafted instructional materials (IMs) are crucial in directing student learning and aligning activities with educational goals. Ensuring the validity of these materials is vital to attaining meaningful learning results. Validity, in this context, refers to how accurately the materials address their intended learning targets. For robotics education, this means that IMs must both facilitate comprehension of essential concepts and maintain student interest and engagement.

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Professional development initiatives centered on robotics have proven effective in strengthening teachers' subject knowledge and boosting their confidence in integrating technology into instruction. Research on the impact of robotics training for science and mathematics educators revealed that participating teachers significantly enhanced their competencies in teaching robotics, which subsequently contributed to noticeable improvements in student performance.

Furthermore, the incorporation of technology in assessment is being considered because traditional assessment methods often rely on pen-and-paper tests, which can be unengaging for students. Innovative assessment tools that are both effective and engaging are necessary to support learners in mastering what they need to learn. Technology can aid learners by providing immediate feedback, enhancing motivation, and facilitating hands-on learning opportunities. Studies have emphasized that interactive technologies can support formative assessments, aligning with the aim of integrating technology in gamified learning materials for assessment purposes.

Despite the numerous benefits associated with integrating robotics into education, several challenges must be addressed. One significant barrier is the disparity in access to resources across different schools and districts. Schools with limited funding may struggle to acquire necessary equipment or provide adequate training for teachers. Additionally, there may be resistance from educators who are unfamiliar with technology or skeptical about its effectiveness.

An additional challenge involves guaranteeing that teacher-created instructional materials are both reliable and impactful. Educators need to continuously assess and enhance their IMs using student input and performance data. This ongoing cycle of improvement demands time, as well as encouragement and backing from school leadership, to cultivate a culture focused on sustained instructional growth.

In conclusion, the integration of robotics into educational settings offers immense potential for enhancing student learning and preparing them for future technological challenges. However, realizing this potential requires careful consideration of instructional material development, teacher training, and assessment strategies. As research in this field continues to evolve, educators and policymakers must work together to address existing challenges and create inclusive, engaging, and effective robotics education programs.

Rationale

This research tackled the issue of potentially low intrinsic motivation among students in STEM fields, particularly within robotics education. To better understand the factors influencing student motivation, a pre-intervention survey was developed to examine different dimensions of intrinsic motivation. The survey assessed students' overall attitudes toward STEM, along with their specific interests, sense of competence, and expectations regarding robotics tasks. Incorporating both quantitative and qualitative methods, the survey sought to reflect the nuanced nature of student motivation, in line with studies highlighting its critical role in enhancing engagement and success in STEM learning (Glynn et al., 2011; Saleh et al., 2019).

The survey administered to Grade 7 students at Legazpi City Science High School before introducing robotics activities into the curriculum during the 2024-2025 academic year. The analysis involved a comprehensive examination of survey results, using statistical measures to identify baseline levels of intrinsic motivation. Additionally, qualitative data from *focus group discussions* (FGDs) has analyzed to uncover specific aspects of STEM subjects that may influence motivation. This dual approach aimed to provide a holistic understanding of students' intrinsic motivation, laying the groundwork for targeted interventions to foster stronger and sustain interest in STEM disciplines.

To counteract possible student disengagement in robotics activities, a gamified robotics module was designed, incorporating elements of competition, challenge, and reward to enrich the learning process. Studies have shown that gamification significantly boosts student motivation and participation by creating a more engaging and interactive learning environment (Deterding et al., 2011; Hamari et al., 2016). The module was structured into progressive levels, with each stage presenting curriculum-based challenges. As students advanced through these levels, they received incentives and acknowledgment for their accomplishments, promoting sustained interest and a sense of achievement.

The gamified robotics learning material implemented within the Grade 7 curriculum at Legazpi City Science High School during the 2024-2025 academic year. Students' progress

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and interactions with the system continuously monitored through gamification analytics, providing insights into their participation, performance, and responses to challenges. A feedback mechanism was established to gather students' perspectives on how the gamified learning material impacts their motivation, interest, and overall learning experience. This approach, combining quantitative analytics with qualitative feedback, informed ongoing adjustments to the gamified module to ensure it remains effective in enhancing student engagement with robotics activities.

To examine the potential effects of robotics activities on academic performance, a robust monitoring system was established to track student achievement in both robotics-related and conventional subjects. This initiative involved close collaboration with subject teachers to develop a grading framework that incorporated students' results from newly introduced robotics topics alongside standard academic assessments. A dedicated tracking platform was regularly updated with performance data, enabling continuous analysis through mid-term and end-term evaluations. This approach allowed for a comprehensive assessment of how the integration of robotics influences overall academic success.

Statistical methods were used to compare academic performance between students engaged in robotics activities and those enrolled in traditional subjects. This approach aimed to uncover any significant influences that robotics may have on academic success by analyzing trends, correlations, and differences in performance metrics. This data-driven approach will foster a deeper understanding of how robotics activities contribute to or potentially influence students' overall academic performance.

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This research centered on the creation and validation of teacher-designed instructional materials for use in robotics education. Inspired by the findings of Ali et al. (2023), who assessed the outcomes of the RoboTeach Extension Project in the Philippines, the study highlighted the critical role of well-designed teacher programs in maintaining quality and effectiveness in robotics instruction. The instructional materials were systematically evaluated based on their content, instructional, and technical quality, following the frameworks and findings established in prior studies by Leonard et al. (2016) and Kucuk and Sisman (2017).

The content quality was assessed based on alignment with curriculum standards, accuracy of robotics concepts, and relevance to real-world applications. Instructional quality focused on the effectiveness of teaching strategies, incorporation of inquiry-based and collaborative learning approaches, and adaptability to diverse learning needs. Technical quality evaluated the user-friendliness of materials, compatibility with available robotics equipment, and integration of appropriate technology.

The validity of these instructional materials was determined through expert review and pilot testing. A panel of education experts, including robotics specialists and experienced teachers, evaluated the materials using a standardized rubric. This process drew on Messick's (1995) framework for assessing validity, adapted specifically for robotics education materials.

The research evaluated the effectiveness of the instructional materials by examining students' knowledge acquisition, skill development, and attitudes toward robotics. To determine learning gains and improvements in conceptual understanding, both pre-tests and

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post-tests were administered before and after the intervention. Skills acquisition was evaluated through hands-on projects and performance tasks, while changes in attitudes was assessed using adapted versions of established STEM attitude scales.

The research explored the potential of robotics education to enhance broader STEM skills and attitudes. Drawing on studies like Williams et al. (2010) and Kandlhofer and Steinbauer (2016), the project investigated how engagement with robotics impacts students' problem-solving abilities, critical thinking skills, and interest in careers.

The study placed a strong emphasis on promoting equity and inclusivity within robotics education, addressing concerns raised by Witherspoon et al. (2016) regarding gender disparities in robotics participation. The instructional materials and gamified modules were designed to appeal to a diverse student population, with care taken to avoid gender stereotypes and to provide relatable role models from various backgrounds.

The study utilized a mixed-methods research design, integrating quantitative data such as survey results, test scores, and performance indicators with qualitative information gathered from focus group discussions, teacher interviews, and student reflections. This comprehensive approach provided a nuanced understanding of the impact of the developed instructional materials and gamified learning experiences on students' engagement, learning outcomes, and attitudes towards robotics and STEM.

This research sought to offer meaningful contributions to the field of STEM education by tackling key challenges related to student motivation, engagement, and academic achievement within the context of robotics instruction. The development and validation of effective, teacher-created instructional materials, coupled with innovative gamification strategies, have the potential to significantly enhance robotics education and foster greater interest in STEM disciplines among students at Legazpi City Science High School and beyond.

Current State of Research in the Field

Robotics in education has experienced notable expansion in recent years, with a growing body of research examining its influence on student learning and instructional practices. Foundational studies, such as Benitti's (2012) review, highlighted the strong educational value of robotics, especially in enhancing students' problem-solving skills and boosting their interest in STEM subjects. The integration of robotics into classroom instruction has been shown to improve students' grasp of complex STEM concepts, while also fostering motivation and collaboration. These early findings have laid the groundwork for more recent investigations that focus on designing and validating instructional materials specifically for robotics, with the goal of optimizing their impact across varied educational settings.

Expanding on this foundation, Witherspoon et al. (2016) explored the influence of gender, personal interest, and previous experience on students' access to learning opportunities in programming during robotics competitions. Their findings underscored the importance of well-designed instructional materials that cater to diverse student backgrounds and interests, a crucial consideration for teachers developing robotics curricula. The study also highlighted the need for materials that promote equity and inclusivity in robotics education.

Ali et al. (2023) carried out a notable study evaluating the impact of the RoboTeach Extension Project on enhancing public school teachers' knowledge and competencies in robotics and automation. Conducted in the Philippines, the project centered on equipping educators with the skills needed to create and utilize robotics instructional materials efficiently. Findings revealed strong participant satisfaction and highlighted the crucial role of extensive teacher training in promoting the quality and success of robotics education.

Leonard et al. (2016) emphasized the importance of content quality in robotics instructional materials by investigating the use of robotics and game design to improve children's self-efficacy, attitudes toward STEM, and computational thinking abilities. Their findings revealed that thoughtfully designed content can greatly influence students' learning outcomes and foster more positive perceptions of robotics and STEM subjects. The study highlighted the need to ensure that instructional content is closely aligned with both curriculum goals and learners' interests to maximize educational impact.

In their 2017 study, Kucuk and Sisman explored the behavioral dynamics between elementary students and teachers during one-to-one robotics instruction. Their research underscored the significance of adapting instructional strategies to meet individual learner needs and demonstrated the critical role of teacher facilitation in optimizing the learning experience. These findings provide meaningful guidance for educators designing robotics instructional materials, pointing to the necessity of flexible, student-centered teaching methods that respond effectively to diverse learning styles.

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Karim et al. (2015) examined the technical aspects of robotics instructional materials in their review of robotics integration in K–12 STEM education. They highlighted the significance of designing materials with intuitive interfaces and technology that aligns with students' developmental levels. Their work offers practical recommendations for educators on how to choose and create robotics resources that are both technically reliable and suitable for the learners' age and abilities.

Erol et al. (2023) performed an extensive meta-analysis to assess how educational robots influence student learning outcomes. The results indicated a moderately strong and statistically significant positive effect (Hedges' g = 0.57) on academic performance, suggesting that the integration of robotics in classroom instruction can improve student achievement. Additionally, the study explored moderating variables such as the learners' grade level and the types of assessments used, offering a deeper understanding of the contexts in which robotics education yields the greatest benefits. These findings offer important recommendations for teachers and curriculum planners seeking to implement impactful robotics programs.

The validity of teacher-developed instructional materials in robotics was indirectly addressed by Messick (1995) in his seminal work on the validity of psychological assessment. Although not specifically focused on robotics, Messick’s validity framework serves as a crucial basis for assessing the quality and effectiveness of robotics instructional materials, offering a structured approach to evaluate their content, instructional design, and technical features.

Ghosh (2019) conducted a systematic analysis of robotics in education, highlighting the importance of aligning robotics instruction with broader educational goals and standards. This research provided a framework for teachers to ensure that their developed materials meet both specific robotics learning objectives and broader educational outcomes.

Mqawass (2018) investigated how robotics education influences students' knowledge, skills, and attitudes, revealing notable gains in their problem-solving capabilities and increased interest in STEM areas. The study highlighted the powerful effect that thoughtfully developed instructional materials can have on student learning outcomes and engagement.

Williams et al. (2010) examined how participating in a robotics summer camp contributed to students' learning of physics concepts and the development of scientific inquiry skills. Their findings highlighted the potential of robotics to enhance both domain-specific knowledge and broader scientific skills, providing guidance for teachers in developing comprehensive instructional materials that address multiple learning objectives.

Kandlhofer and Steinbauer (2016) further investigated how robotics education influences students' perceptions and attitudes toward STEM-related fields. Their study revealed positive changes in students' perceptions of technology and engineering careers following participation in robotics programs, underscoring the importance of designing instructional materials that not only convey technical knowledge but also foster positive attitudes towards STEM fields.

In response to the growing need for effective evaluation methods in robotics education, Grover and Pea (2013) conducted a review of computational thinking practices within K–12 settings. Their work provided valuable insights into assessing complex skills developed through robotics education, offering guidance for teachers in developing assessment strategies aligned with their instructional materials.

Funa and Ricafort (2019) examined how gamification can improve robotics education by studying its application in an undergraduate general education course. Their findings showed that incorporating game-based strategies significantly boosted student engagement and academic performance. This suggests that educators can enhance motivation and learning outcomes in robotics instruction by integrating game elements into their teaching materials.

Bers et al. (2014) explored the development of computational thinking and hands-on experimentation within robotics programs designed for young children. Their research highlighted the importance of age-appropriate instructional materials and the potential for robotics education to foster foundational STEM skills from an early age, providing valuable insights for teachers developing materials for younger students.

Recent research has increasingly focused on middle school education, recognizing this stage as critical for introducing robotics. Martinez et al. (2023) investigated how a robotics curriculum influenced middle school learners' problem-solving abilities and found notable enhancements following their participation in interactive, hands-on learning experiences. Additionally, Li and Wang (2022) investigated how robotics promotes collaborative learning

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and teamwork among middle school students, highlighting its potential to develop essential interpersonal skills.

Motivation has emerged as a key area of interest within this research field. Johnson et al. (2021) found that gamified robotics activities positively influence students' intrinsic motivation and engagement in STEM subjects. Their study demonstrated that when students participate in gamified learning experiences involving robotics, they were more motivated compared to traditional teaching methods.

Academic performance related to robotics education has also been a focus of research. Smith and Davis (2022) conducted a longitudinal study examining academic outcomes for students involved in robotics activities over time. Their findings revealed positive correlations between engagement in robotics and improved performance in related subjects, suggesting that integrating robotics into curricula can enhance overall academic achievement.

These studies collectively emphasized the importance of developing high-quality, valid, and effective instructional materials in robotics education. They emphasize the importance of developing instructional materials that are rich in content, grounded in effective teaching practices, and technically suitable, while also being responsive to the varied needs and interests of learners. The research underscored the potential of robotics education to enhance students' knowledge, skills, and attitudes towards STEM fields, if it is supported by well-designed and thoughtfully implemented instructional materials.

Problem in the Field

Despite the growing interest in robotics education and its potential benefits, several challenges persisted in the field, particularly concerning teacher-developed instructional materials (IMs) in robotics and their effectiveness on students' knowledge, skills, and attitudes (KSA).

A key challenge encountered was the absence of standardized, high-quality instructional materials for robotics education. Numerous educators faced difficulties in developing effective IMs that equally addressed content accuracy, instructional soundness, and technical design. This issue was compounded by the fast-paced advancements in robotics technology, which made it challenging for teachers to maintain the relevance and timeliness of their instructional materials.

Another major concern was the insufficient training and support provided to teachers for developing and utilizing robotics instructional materials. A considerable number of educators did not possess the required competencies or confidence to effectively incorporate robotics into their teaching. As a result, this often led to inconsistent or suboptimal implementation in classrooms, which could hinder students from fully benefiting from robotics-based learning.

The high cost of robotics equipment and resources was another major barrier. Many schools, especially those in underfunded areas, cannot afford the necessary tools and materials for comprehensive robotics education. This resulted in unequal access to quality robotics education, which may contribute to an expanding achievement gap among students from varying socioeconomic backgrounds.

There was also a lack of clear guidelines and standards for assessing the validity and effectiveness of teacher-developed robotics IMs. Without proper evaluation methods, it is challenging to determine whether these materials were truly meeting educational objectives and improving students' KSA in robotics.

The integration of robotics education into existing curricula possessed another challenge. Many schools struggled to find the right balance between teaching traditional subjects and incorporating robotics, often due to time constraints and pressure to meet standardized testing requirements.

Student engagement and motivation can be inconsistent in robotics education. While some students were highly enthusiastic about robotics, others may find it challenging or uninteresting. Developing IMs that catered to diverse learning styles and interests remained a significant challenge for educators.

There was also a gender gap in robotics education, with female students often underrepresented in robotics classes and activities. Creating inclusive and engaging IMs that appealed to all students, regardless of gender, was an ongoing challenge in the field.

The rapid pace of technological advancement in robotics made it difficult for educational institutions to keep up. By the time schools acquired certain robotics technologies and developed corresponding IMs, newer technologies may have already emerged, potentially making the materials outdated.

Evaluating student learning in robotics education presented another challenge, as conventional assessment methods often failed to reflect the hands-on skills and problem-solving competencies cultivated through robotics activities. Creating assessment tools that accurately aligned with the experiential and interactive nature of robotics remained a persistent issue. Additionally, the absence of longitudinal studies examining the long-term effects of robotics education on students' academic and career trajectories posed a significant gap. This lack of evidence made it more difficult for educators and advocates to convincingly demonstrate the value of robotics education to policymakers and stakeholders.

Lastly, there was a need for better collaboration between educators, researchers, and industry professionals in developing effective robotics IMs. The disconnect between these groups can result in IMs that do not fully align with current industry practices or research findings.

Tackling these challenges was essential to propel the progress of robotics education and to guarantee that students can maximize the benefits of robotics as a tool for enriching their learning experiences and equipping them for future careers in STEM-related fields.

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Objectives of the Study

These objectives aimed to comprehensively evaluate teacher-created instructional materials for robotics education, assessing the quality, validity, and impact on student learning outcomes. The study sought to provide insights that can improve robotics instruction and contribute to the development of effective educational resources in this field, with the following sub – objectives:

1. Describe the features of the teacher-developed learning materials in robotics along:

   a. Content quality

   b. Instructional quality

   c. Technical quality

2. Determine the validity of the teacher-developed learning materials in robotics along content quality, instructional quality, and technical quality.

3. Determine the effectiveness of the utilization of the teacher-developed learning materials in robotics along:

   a. knowledge gained

   b. skills acquired

   c. attitude towards robotics

4. Recommend measures to enhance the instruction in robotics.

MATERIALS AND METHODS

This study employed a mixed-methods research design that integrated both descriptive and developmental approaches to evaluate the validity and effectiveness of teacher-developed instructional materials (IMs) in Grade 7 robotics education. The choice of a mixed-methods design was driven by the complex and multifaceted nature of the research, which aimed to assess not only the structural and pedagogical quality of the instructional materials but also their impact on student learning outcomes in terms of knowledge, skills, and attitudes (KSA). The descriptive aspect of the research was utilized to examine the characteristics of the instructional materials across three primary dimensions: content quality, instructional quality, and technical quality. This facilitated a structured analysis of the materials' alignment with curriculum standards, their effectiveness in supporting student engagement and understanding, and their usability within a classroom setting. The developmental component of the research, as defined by Richey (1994), focused on the systematic design, creation, and refinement of instructional resources. This process involved integrating key educational features such as contextual relevance, inquiry-based learning, sustainability themes, and gamification strategies to ensure student-centered, experiential, and reflective learning opportunities.

The study relied on both quantitative and qualitative data collection methods to ensure comprehensive findings. A quasi-experimental design incorporating pretest-posttest measures was employed to determine the instructional materials' impact on student learning. Quantitative instruments included a researcher-developed 25-item multiple-choice test to measure knowledge gains, a performance rubric to assess skill acquisition through hands-on robotics tasks, and an attitude inventory scale to measure students' perceptions, interest, and motivation in learning robotics. In parallel, qualitative data were gathered through student journaling, focus group discussions (FGDs), teacher interviews, and juror comment sheets to provide deeper insight into students' and educators' experiences and perceptions of the instructional materials. This mixed-methods approach allowed for triangulation of findings, contributing to a richer and more nuanced understanding of how the IMs functioned in an authentic learning environment.

The instructional materials evaluated in this study included seven teacher-developed modules that featured robotics learning guides, interactive activity sheets, gamified PowerPoint presentations, and structured lesson exemplars aligned with the Most Essential Learning Competencies (MELCs) for Grade 7 Robotics. The materials were developed by the researcher using curriculum-aligned content and innovative pedagogical strategies, and were later refined based on expert reviews and pilot classroom trials. Their development was grounded in several theoretical frameworks. Constructivist learning theories, particularly those by Piaget and Vygotsky, informed the hands-on and collaborative activities designed to foster knowledge construction through experience. Gamification theory, particularly the principles outlined by Deterding et al. (2011), guided the integration of game elements such as points, badges, and leaderboards to enhance student engagement. Additionally, sustainability pedagogy provided the thematic direction for real-world problem-solving tasks, such as designing eco-friendly robotic models and engaging in ethical discussions on technology's environmental impact.

The primary sources of data included the instructional materials themselves, the Grade 7 student participants, the teachers who implemented the materials, and a panel of expert jurors who evaluated the materials using standardized tools. The instructional materials were assessed based on content quality (accuracy, clarity, alignment with MELCs), instructional quality (effectiveness of teaching strategies, engagement level, differentiation), and technical quality (layout, usability, and compatibility with technology platforms). Grade 7 students from Legazpi City Science High School, numbering 175 across five sections, served as the main participants for assessing the effectiveness of the IMs. Among them, 35 students were chosen to undergo the pretest-posttest implementation. These students, aged 12 to 13, represented diverse learning backgrounds, with some having minimal exposure to robotics prior to the study. Their varied profiles made it possible to analyze the materials' effectiveness across different learner types. Additionally, four STEM teachers participated in the classroom implementation of the materials. Their practical insights were collected through surveys and semi-structured interviews, which focused on the usability, strengths, and challenges encountered in delivering the robotics lessons.

To ensure objectivity in validating the instructional materials, a panel of six expert jurors was purposively selected based on their academic and professional expertise in science and technology education. This group included education program supervisors, master teachers, university faculty, and curriculum specialists. They assessed the IMs using an Evaluation Checklist and a Validation Rubric adapted from the Department of Education's Learning Resources Management and Development System (DepEd LRMDS). Both tools covered content, instructional, and technical criteria and used Likert-type scales. A 5-point scale (1 = strongly disagree, 5 = strongly agree) was used for the checklist, while the rubric applied a 4-point scale (1 = not acceptable, 4 = highly acceptable) with descriptive indicators. The Content Validity Index (CVI) was calculated to determine the level of agreement among jurors. Items with a CVI of 0.80 or higher were deemed valid and retained, while those falling below this threshold were revised based on juror suggestions.

To measure knowledge gained, a multiple-choice test was constructed using a Table of Specifications (TOS) to ensure coverage of key robotics concepts and cognitive levels. An initial pool of 70 items was drafted and evaluated by expert jurors. After a pilot test conducted with 80 Grade 7 students from Legazpi City National High School (40 from the upper group and 40 from the lower group), the test was refined based on difficulty and discrimination indices. Twenty-five high-performing items were retained for the pretest and posttest administered to the 35 participating students. A Z-test for the difference between means was used to analyze the statistical significance of knowledge gains, with a p-value threshold of 0.05.

Student skill development was evaluated using a performance-based assessment rubric during hands-on robotics tasks such as wiring circuits, assembling components, or writing simple code using Arduino platforms. The rubric assessed criteria such as task completion, sequencing, logical problem-solving, creativity, and collaboration. Scores were analyzed using descriptive statistics, including mean and standard deviation, to summarize performance trends. To gauge attitudinal shifts, a 15-item Attitude Inventory Scale was administered before and after the intervention. The scale measured students' interest in robotics, motivation to learn, confidence in their skills, and perceived usefulness of robotics in their future careers. Items were scored using a 5-point Likert scale, and average scores were compared across pre- and post-surveys to identify changes in attitudes.

Qualitative data were collected to supplement and deepen the interpretation of quantitative findings. Students maintained structured journals throughout the intervention period, documenting their reflections on learning tasks, group activities, and technical challenges. These entries were later subjected to thematic analysis to extract recurring patterns and personal insights. Focus group discussions (FGDs) with students were conducted online via Google Meet to further explore their experiences and attitudes toward the robotics materials. These discussions often yielded rich feedback, such as preferences for gamified activities, difficulties in understanding certain concepts, and suggestions for clearer instructions or visuals.

Teachers who implemented the materials provided input through interviews and FGDs as well. Interview guides included questions on the clarity of instructional objectives, alignment with MELCs, student engagement, ease of use, and classroom management during robotics activities. Teachers highlighted both strengths, such as increased student motivation and enthusiasm, and challenges, such as limited access to devices or the need for

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differentiated tasks. Their feedback was also analyzed thematically and used to propose refinements for future iterations of the materials. Additionally, the accompanying lesson plans were reviewed by expert jurors to ensure alignment with the 7E instructional model. Evaluators assessed whether each phase—elicit, engage, explore, explain, elaborate, extend, and evaluate—was clearly addressed and whether instructional strategies were age-appropriate and learner-centered.

The data analysis involved both descriptive and inferential statistical techniques. Mean scores, standard deviations, and frequency distributions were used to describe pretest and posttest results, skill rubric scores, and attitude inventory responses. The Z-test was conducted to determine the significance of knowledge gains. Reliability of the instruments (pretest-posttest and attitude survey) was evaluated using Cronbach's alpha, with scores above 0.70 indicating acceptable internal consistency. For content validation, the CVI provided a quantitative measure of inter-rater agreement on the quality of the instructional materials. These robust analytical techniques ensured that the findings were statistically sound and reflective of the instructional materials' true impact.

Ethical protocols were rigorously followed throughout the research process. Prior to data collection, approval was obtained from the school administration, and informed consent was secured from all student participants and their parents or guardians. Teachers and jurors also signed consent forms outlining their voluntary participation and the confidentiality of their responses. Participants were assured that their involvement or withdrawal would not affect their academic standing or professional roles. All personal identifiers were removed from the

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data to protect participant anonymity. Digital records were stored in password-protected folders, while printed materials were secured in locked filing cabinets. Upon completion of the study, participants were debriefed and provided with a summary of findings, allowing them to reflect on their contributions and outcomes.

The sample size was determined based on the statistical requirements of the Z-test and content validation process. Thirty-five students participated in the main study, which was sufficient to assess learning gains and conduct item analyses. Eighty students were involved in the pilot testing phase for item validation. Ten expert jurors participated in the validation of instructional materials, lesson plans, and assessment tools—an adequate number based on validation guidelines for educational materials. Overall, the sample size, tools, and methodologies used were all selected to ensure rigor, objectivity, and relevance to the research objectives.

RESULTS AND DISCUSSION

The study on the validity and effectiveness of teacher-developed instructional materials (IMs) in Grade 7 Robotics yielded significant insights into the transformative impact of well-crafted, contextually relevant educational resources on student learning outcomes. Utilizing a pretest-posttest experimental design, the research revealed a substantial improvement in students' academic performance, skill acquisition, and attitude toward robotics following the implementation of the instructional materials. At the beginning of the study, students scored an average of 9.1 out of 25 on the pretest, translating to a mastery level of just 36.3%. This baseline reflected limited understanding of fundamental robotics concepts and minimal prior exposure to hands-on robotics activities. However, after exposure to the teacher-developed instructional materials, the posttest scores surged to an average of 22.6 out of 25, or 90.3%. This significant gain, verified through a Z-test for the difference between means ($Z = 19.35$, $p < 0.05$), confirmed the instructional materials' effectiveness in enhancing student comprehension, retention, and practical application of robotics principles.

The improvement in scores was not confined to high-achieving students. The lowest pretest score of 2 (8%) improved to 19 (76%) in the posttest, demonstrating that struggling learners benefited significantly from the materials. At the upper end of the performance spectrum, the highest score improved from 16 (64%) to a perfect 25 (100%), indicating that the materials also supported deeper learning for advanced students. The median score rose from 9 to 23, while the standard deviation dropped from 3.1 to 1.6, suggesting not only an overall rise in scores but also a more equitable distribution of achievement across the class. This reduction in score variability reflects a more inclusive learning experience, where fewer students lagged behind and the instructional delivery met the needs of learners across the performance continuum. The structured design, clear scaffolding, and inquiry-driven activities embedded in the instructional materials contributed to this uniformity, ensuring that all students, regardless of initial ability, were supported in mastering robotics content.

The study's findings are consistent with related Philippine-based research that emphasizes the importance of localized and teacher-created learning resources. Studies by Reyes (2020), Santos and Villanueva (2021), and Mendoza (2023) similarly found that when teachers design instructional materials tailored to their students' cultural and academic contexts, learning becomes more meaningful and engagement levels rise. In the same vein, Dela Cruz and Ramirez (2022) reported improved STEM performance and participation in public schools following the introduction of teacher-developed robotics kits. These collective insights reinforce the idea that teacher-led instructional design can lead to more relevant, accessible, and effective learning experiences, especially in technologically complex fields such as robotics.

Beyond test scores, the implementation of the instructional materials fostered the development of essential scientific and engineering skills. Performance-based assessments conducted throughout the intervention revealed that students demonstrated proficiency in observation, classification, measurement, experimentation, and logical reasoning. In activities such as "Powering Up: Exploring Circuits" and "The SC Journey," students accurately identified circuit components, used tools like multimeters, and constructed working circuits. They were able to predict electrical behavior, infer causes of circuit failure, and systematically record their findings, aligning their performance with scientific practices. They also demonstrated the ability to troubleshoot errors in wiring and code, indicating not just procedural competence but also analytical thinking and problem-solving ability.

As students progressed to more complex tasks—such as those in "The PC Connection" and "The Arduino Quest: Build Your World"—they applied their knowledge of electronics and programming to real-world automation scenarios. Students explored Arduino-based systems, configured sensors, analyzed digital outputs, and debugged both hardware and software. This progression from conceptual understanding to real-world application is a key indicator of deep learning. Students also collaborated effectively in team-based challenges, showcasing their communication skills and their ability to divide tasks, share ideas, and synthesize feedback. In activities like "LED Blinking" and "Buzzer-Building," students engaged in iterative design processes that required continuous testing and refinement—hallmarks of the engineering design cycle. These activities bridged classroom learning with actual STEM applications, preparing students not only for academic success but for future participation in technology-driven fields.

Nevertheless, the study also highlighted areas for further growth. Although students showed competence in most performance domains, certain skills—such as controlling variables and interpreting experimental data—needed further reinforcement. While learners were able to manipulate independent and dependent variables, their ability to isolate and control extraneous factors in experimental setups varied. Some students also struggled with drawing conclusions from graphical data or identifying patterns in multivariable experiments. These findings underscore the need to embed more structured data analysis tasks and guided inquiry in robotics instruction, enabling students to develop higher-order thinking skills alongside technical proficiency.

Equally important in this study was the assessment of student attitudes toward robotics, which provided a nuanced understanding of how the instructional materials influenced students' motivation, confidence, and interest in STEM. Using an attitude inventory that explored dimensions such as interest, confidence, engagement, perceived usefulness, teamwork, and future aspirations, the study revealed a generally positive shift across all domains. Students expressed enjoyment in learning about robotics, curiosity about real-world applications, and excitement about exploring new technologies. The average rating in the dimension of interest was 3.83 out of 5, indicating that students generally found robotics engaging and were intrigued by how it connects to modern innovations.

However, while students reported strong interest and enthusiasm during class, their willingness to explore robotics independently or participate in extracurricular activities such as competitions was more moderate. The dimension of confidence yielded a lower average score of 3.05, suggesting that while students were comfortable with basic hardware and software operations, they remained hesitant about solving programming problems independently or explaining robotics concepts to peers. This points to a need for more scaffolding in fostering self-efficacy—particularly through peer teaching, open-ended projects, and guided reflection. Engagement and motivation scored relatively high (3.75), but again, students showed a tendency to stay within classroom-bound interest rather than take initiative beyond formal instruction.

Students also demonstrated a strong appreciation for the collaborative nature of robotics. In the domain of teamwork and collaboration, the average score was 4.20, reflecting that students valued peer input, enjoyed working in teams, and felt comfortable sharing ideas.

However, the area of leadership development within team activities received slightly lower ratings, suggesting that while students participated actively, opportunities to take on leadership roles could be further enhanced. Similarly, in the domain of problem-solving, students rated the importance of learning from mistakes and the satisfaction of solving technical problems highly, but expressed less confidence in independently fixing robotic errors or experimenting with solutions—highlighting a need for more structured troubleshooting experiences.

The perceived usefulness of robotics instruction scored 3.81 on average, with students acknowledging that robotics helped them understand STEM better and provided skills relevant to future careers. However, lower scores for items like "I can connect robotics lessons with what I learn in other subjects" indicated that cross-curricular integration could be improved. Encouraging interdisciplinary learning that links robotics to mathematics, communication, and science would help solidify its place in the broader educational framework. On the dimension of future interest, students showed moderate levels of desire to pursue robotics beyond the classroom, with the lowest ratings recorded in their willingness to join competitions or consider robotics careers. This suggests a need for more exposure to real-world applications, industry mentors, and career pathways in engineering and technology.

The strengths of this study lie in its comprehensive methodology, use of validated tools, and integration of both quantitative and qualitative data. The application of rigorous item analysis, expert validation using the Content Validity Index (CVI), and detailed

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performance-based assessments ensured that findings were both statistically sound and pedagogically grounded. The incorporation of student and teacher voice through interviews and focus group discussions added depth and authenticity to the conclusions. However, limitations such as the small sample size, single-school setting, and short-term nature of the study must be acknowledged. Further research involving a broader and more diverse sample, as well as longitudinal tracking of knowledge retention, would strengthen the generalizability and applicability of the findings.

The study was underpinned by several theoretical frameworks that shaped both the instructional materials and their evaluation. Constructivist Learning Theory guided the design of lessons that prioritized experiential learning, scaffolding, and reflection. Active learning principles ensured that instruction was learner-centered, inquiry-based, and grounded in real-world problem-solving. Gamification theory, applied through interactive PowerPoint slides, simulations, and point-based challenges, increased motivation and engagement. Assessment theory provided the structure for valid and reliable evaluation of learning outcomes, while the Technology Acceptance Model (TAM) helped interpret student and teacher feedback on the materials' usability and relevance.

Considering the findings, several recommendations emerge for enhancing robotics instruction. First, efforts should be made to align instructional materials more explicitly with cross-curricular competencies, helping students see the interconnectedness of robotics with other disciplines. Second, instructional strategies should be expanded to include more real-world robotics applications, career exploration, and industry exposure. This can include inviting guest speakers, integrating virtual field trips, or organizing hackathons and innovation fairs. Third, developing students' confidence in independent problem-solving and peer teaching requires consistent practice in open-ended tasks and leadership roles within collaborative projects. Fourth, expanding access to resources and training for teachers is crucial to ensure wider adoption of effective instructional materials across different school contexts.

The use of teacher-developed instructional materials in Grade 7 Robotics significantly enhanced students' academic performance, technical skills, and attitudes toward STEM learning. These materials, validated by expert jurors and supported by empirical data, proved to be inclusive, engaging, and responsive to students' learning needs. The pretest-posttest results demonstrated a remarkable leap in knowledge acquisition, while performance tasks revealed students' growing proficiency in real-world applications of robotics. Attitudinal gains indicated a shift in students' perception of robotics from intimidating to accessible and even enjoyable. Together, these outcomes affirm the potential of empowering teachers as curriculum designers and the value of localized, context-sensitive instructional resources in improving STEM education. With appropriate institutional support, professional development, and curriculum integration, these materials can serve as a model for enriching STEM instruction and preparing learners for the technological demands of the future.

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CONCLUSION

Based on the results of the study titled *"The Validity and Effectiveness of the Instructional Materials in Robotics of Grade 7"* the following conclusions are drawn in relation to the stated objectives:

1. On the features of the teacher-developed instructional materials in Robotics:

a. **Content Quality.** The instructional materials were found to be highly aligned with the Most Essential Learning Competencies (MELCs) for Grade 7 Robotics. The content was accurate, appropriate to the learners' level, and integrated relevant concepts in electronics, programming, and automation. The materials also promoted critical thinking and incorporated values-based learning, which enhanced the overall substance of the content.

b. **Instructional Quality**. The materials demonstrated strong instructional coherence and learner engagement. Lessons were sequenced logically and scaffolded properly using the 7E model (Elicit, Engage, Explore, Explain, Elaborate, Extend, Evaluate). Activities supported differentiated instruction, active learning, and collaboration. Students were provided with clear objectives, interactive tasks, and meaningful assessment tools.

c. **Technical Quality**. The materials were user-friendly, visually appealing, and accessible. The layout and design were consistent, instructions were clear, and the integration of gamified PowerPoint modules and simulations enhanced student interest. While a few suggestions were raised by jurors regarding image clarity, the overall technical quality was rated "Very Satisfactory" by expert validators.

2. On the validity of the instructional materials: The instructional materials were validated using evaluation tools adapted from DepEd LRMDS. The computed Content Validity Index (CVI) for all components exceeded the benchmark of 0.80, indicating high agreement among experts regarding the content, instructional approach, and technical design of the materials. Therefore, the teacher-developed instructional materials were considered valid and suitable for use in the Grade 7 Robotics curriculum.

3. On the effectiveness of the instructional materials in improving student outcomes:

a. **Knowledge Gained**. Students showed significant improvement in their knowledge of Robotics concepts. Pretest and posttest results revealed an increase from a mean score of 36.3% to 90.3%, which was statistically significant based on the Z-test conducted. This indicates that the materials effectively enhanced students' theoretical understanding of Robotics.

b. **Skills Acquired**. Through performance-based tasks, students demonstrated proficiency in Robotics-related skills such as programming, logical sequencing, robot assembly, and troubleshooting. Assessment rubrics showed that most learners reached "Proficient" or "Exemplary" levels, proving the effectiveness of the materials in developing practical competencies.

c**. Attitude Towards Robotics**. The attitude inventory showed a positive shift in students' interest, motivation, and confidence in Robotics after the implementation of the instructional materials. Students found Robotics more enjoyable and perceived it as useful for future careers, which suggests the materials fostered a more favorable disposition toward STEM.

4. On recommended measures to enhance instruction in Robotics:

1. Continue developing teacher-made, contextualized instructional materials tailored to student needs and local settings.
2. Provide regular teacher training on Robotics content, pedagogy, and material development using DepEd standards.
3. Incorporate more real-world and interdisciplinary applications of Robotics to sustain interest and relevance.
4. Ensure access to Robotics kits, simulation tools, and ICT support to allow full implementation of materials.
5. Include continuous monitoring and improvement of materials through classroom feedback, student performance data, and expert review.

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