Supplementary Workbook in Learning Mathematics

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The Philippines continues to confront a persistent challenge in raising students' mathematical proficiency. Despite numerous interventions over the years, Filipino learners still trail behind their peers in neighboring countries. Results from the Program for International Student Assessment (PISA) 2022 revealed no significant improvement compared with the country's performance in 2018. Fewer than one in four Filipino students achieved the minimum proficiency level in mathematics, reading, and science. Although average scores across all subjects increased slightly, the gains were limited to single-digit improvements, and overall performance remained below the OECD average. Mathematics, in particular, registered only a modest increase, rising from 353 in 2018 to 355 in 2022 (Chi, 2023). This persistent gap has been extensively documented in Philippine educational research (Valle, 2024; Ignacio & Bajet, 2025; Jaudinez, 2019; dela Cruz & Hernandez, 2023; Carandang et al., 2024; Mocorro & Mocorro, 2025; Vistro-Yu et al., 2025), with scholars underscoring the urgency of implementing more effective and sustainable solutions. In response, several

studies have recommended pedagogical innovations, including the design of supplementary workbooks as instructional aids (Ibañez et al., 2021; Lomibao, 2016; Magayon & Tan, 2016; Malicoban et al., 2021; Besana et al., 2022; Ayado & Berame, 2022).

Within STEM programs, calculus occupies a pivotal position, with trigonometry serving as a foundational prerequisite. Students are expected to demonstrate mastery of trigonometric concepts, as these form the basis for higher-order mathematical reasoning in calculus and related fields. A robust grasp of trigonometric principles enables learners to approach advanced coursework with greater confidence and problem-solving capacity. However, evidence suggests that many students encounter persistent difficulties in this area. Nanmumpuni and Retnawati (2021), for example, reported that learners across a wide range of cognitive levels and creative thinking skills consistently struggled with fundamental trigonometric concepts. Their findings highlight a widespread vulnerability to errors in problem-solving, thereby underscoring the need for structured pedagogical support and targeted instructional materials.

One strategy with demonstrated effectiveness in strengthening mathematical understanding is the systematic use of workbooks (Yeh et al., 2019). Workbooks provide learners with sequenced exercises that reinforce classroom instruction and gradually build competence in complex concepts. By incorporating illustrative examples, guided practice, and progressively challenging tasks, they not only address common misconceptions but also consolidate students' foundational knowledge. Importantly, well-designed workbooks can be adapted to diverse learning styles, offering visual, concrete, and applied problem-solving opportunities to students who may struggle with abstract reasoning (Malicoban et al., 2021; Besana et al., 2022). Furthermore, they support both independent and collaborative modes

of learning: students may work at their own pace, monitor their progress, and revisit areas of difficulty, while teachers can utilize workbook outputs to diagnose learning gaps and deliver targeted feedback.

The integration of such resources into the mathematics curriculum has been shown to foster critical thinking, increase engagement, and strengthen the link between theoretical knowledge and practical application (Ayado & Berame, 2022; Rivera, 2023). Taken together, the evidence suggests that supplementing traditional instruction with research-informed, well-structured workbooks offers a pragmatic and scalable approach to addressing the persistent learning gaps of Filipino students in mathematics and trigonometry.

Enhancing Learning in Mathematics through Workbooks and Supplemental Materials

Difficulties in learning trigonometry are rooted in several interrelated factors. Irawan et al. (2019) noted that students' disinterest often arises from weak comprehension of fundamental concepts, leading to discouragement and declining motivation. This aligns with the findings of Nanmumpuni and Retnawati (2021), who observed that students across all levels of creative thinking ability struggled with trigonometric concepts, committing errors regardless of cognitive capacity. Similarly, Arhin and Hokor (2021) reported that learners frequently failed to transfer rudimentary knowledge into practical applications, thereby exposing the gap between basic comprehension and problem-solving proficiency.

Further studies have identified more specific barriers to trigonometric learning. Rahayu and Rosjanuardi (2022) highlighted epistemological obstacles in analytic trigonometry arising from insufficient

mastery of prerequisite topics. Nurmeidina and Rafidiyah (2019) likewise identified poor problem comprehension, misapplication of concepts, and limited familiarity with problem formats as significant barriers. Complementing these insights, Adawiyah and Kurniasari (2020) demonstrated that variations in learning styles influence how effectively students acquire trigonometric knowledge. Haryani et al. (2022) also noted the frequent difficulty students encounter in identifying and applying appropriate formulas to solve specific problems.

These learning difficulties are further compounded by systemic issues related to pedagogy and curriculum. Maghirang and Banzon (2023) emphasized that performance in trigonometry depends on strong foundational knowledge, active learning strategies, and effective teaching approaches. Similarly, Delima (2022) underscored the continued difficulty of trigonometry for both students and teachers, despite its acknowledged importance in the curriculum. Empirical evidence reflects these challenges: Batidor and Casinillo (2021) found that achievement in trigonometry consistently remained below satisfactory levels, pointing to the need for stronger teacher preparation. Likewise, Padernal and Diego (2020) reported that pre-calculus performance remained only average across diverse student backgrounds, underscoring the broader necessity for instructional enhancement.

To address these challenges, workbooks and other supplemental learning materials have been recognized as effective tools for improving student performance. Gyamfi et al. (2021) described workbooks as instructional resources that scaffold learners' progression through complex concepts, while Bordia (2022) highlighted their role in reinforcing conceptual clarity through varied exercises. Collado and Abubo (2021) found that students using workbooks outperformed peers who relied solely

on lectures, while Benitez (2020) affirmed that well-designed workbooks—meeting standards of content quality, examples, and assessment—contributed to improved competency. However, Mithans et al. (2022) noted that students tended to engage with workbooks more frequently in school than at home, suggesting a need for strategies that promote their broader use beyond classroom contexts.

Beyond conventional workbooks, diverse supplemental learning resources have also demonstrated positive effects on teaching and learning. Agbunag (2022), for instance, showed that contextualized and localized e-learning resources in Physics improved instructional processes, recommending their continuous adaptation. Similarly, Decoriña (2022) validated supplementary learning packages that supported independent learning during the "new normal," advocating for ongoing refinement to enhance quality. Talas and Panoy (2023) further confirmed that supplemental materials strengthened critical thinking, as evidenced by significant improvements in pre- and post-test results.

The integration of culturally relevant and subject-specific supplemental resources has likewise been shown to enhance student engagement and motivation. Besonia et al. (2023) found that culturally grounded materials fostered stronger connections between personal experiences and academic learning, particularly in digital environments. Saldo and Walag (2023) emphasized that supplemental approaches embedded in classroom instruction not only improved learning outcomes but also supported the development of 21st-century skills. In a similar vein, Alejandria et al. (2023) reported positive learner feedback on an educational tool for mastering the periodic table, which students described as both enjoyable and effective.

The validation of workbooks across disciplines further underscores

their instructional value. Utami et al. (2023) reported that Generation Z students responded positively to workbook use, while Fran (2022) demonstrated that validated workbooks effectively supported both teachers and students, enhancing research-based learning. Sulistina and Salimaturosidah (2023) confirmed the feasibility of their workbook through expert evaluation and readability tests, while Rahayu et al. (2022) validated an e-workbook as effective in promoting collaboration and critical thinking. Similarly, Araza and Magnaye (2023) showed that MELCS-based workbooks effectively bridged theoretical and practical learning.

Technological innovations have further advanced workbook development. Akouaydi et al. (2021) demonstrated that digital workbooks incorporating tactile devices improved both feedback and learning processes. Perkins et al. (2023) emphasized their role in promoting self-directed learning and formative assessment, while Greubel et al. (2023) concluded that well-designed digital workbooks enhanced academic relevance and increased student enjoyment.

Teacher-developed and subject-specific workbooks have also proven effective in meeting learner needs. Comay-Ao et al. (2019) designed an arithmetic workbook highly rated by master teachers for its responsiveness to learners' difficulties, while Inocencio and Calimlim (2021) documented significant gains in Science performance from teacher-developed workbooks. Basilio and Sigua (2022) confirmed the utility of validated instructional modules, and Bernido (2020) found that inquiry-based materials fostered deeper learning. Likewise, Manzano (2023) reported excellent ratings for instructional materials in both content quality and pedagogical effectiveness.

Other studies reinforced the broader usability and relevance of workbook-like resources. Lacea and Buscano (2023) highly rated Learning

Activity Sheets (LAS) for appropriateness and practicality, while Navarra et al. (2022) advocated greater TESDA investment in effective workbook resources. Dominado et al. (2023) emphasized their engaging potential in contexts lacking modern instructional tools, and Rogayan and Dollete (2019) confirmed workbook acceptability in terms of coherence and usefulness. Similarly, Homillano (2023) reported significant learning gains in Science, Technology, and Society following the integration of an instructional module, highlighting the sustained value of workbook development in improving learning outcomes.

Development and Validation of TRIBOO: A Supplementary Workbook for Learning Basic Concepts of Trigonometry

This study sought to address the low proficiency of Grade 12 STEM students in trigonometry through the development and validation of TRIBOO, a supplementary workbook designed to strengthen foundational understanding of basic trigonometric concepts. The workbook was subjected to validation by mathematics teachers from various schools to ensure content accuracy, pedagogical soundness, and instructional relevance. It features clearly stated lesson objectives, concise explanations, illustrative examples, structured exercises, and real-world application problems. Together, these components aim to enhance conceptual clarity, provide meaningful practice, and support students in developing deeper and more durable learning in trigonometry.

Methodology

This study employed a quantitative research design, a systematic and empirical approach that describes, explains, and predicts phenomena

using numerical data. Specifically, a quasi-experimental one-group pre-test–post-test design was utilized to compare students' performance before and after the use of TRIBOO, thereby determining its effectiveness in improving learning outcomes.

The research was conducted in the Senior High School Department of a public university in Laguna, Philippines. Convenience sampling, a non-probability sampling technique, was applied to select participants who were readily accessible. A total of 35 Grade 12 STEM students participated in the implementation of TRIBOO, while five expert validators in mathematics education were engaged to evaluate the workbook's content, instructional soundness, and overall quality.

Table 1
Six (6) phases of ASSURE model

Phase 1: Analysis	A survey and pre-test were conducted to identify the least learned concepts and assess students' proficiency in the basic concepts of trigonometry.
Phase 2: Stating Objectives	The results of the survey and pre-test served as the basis for the specific objectives of the workbook.
Phase 3: Selecting Method and Materials	TRIBOO is made available in both printed and digital formats, and its content follows a structured sequence for each topic.
Phase 4: Utilizing the Method	The workbook content was organized using the Most Essential Learning Competencies (MELCs) of the STEM strand. Each topic begins with a pre-assessment to gauge prior knowledge, followed by a recall activity, a concise lesson, and exercises to reinforce understanding and build mastery.
Phase 5: Requires learners' participation	TRIBOO incorporates engaging activities aligned with its learning objectives, including hands-on exercises, problem-solving tasks, and open-ended questions for self-reflection.
Phase 6: Evaluation	After rigorous validation by five experts, the workbook was pilot-tested with Grade 12 STEM students, who then completed a post-test.

Data collection involved a 15-item pre-test administered to assess students' baseline proficiency in trigonometry and identify areas of difficulty. Following this, TRIBOO was introduced as the intervention, after

which a post-test was conducted to measure learning gains and proficiency improvement. The study was systematically guided by the six phases of the ASSURE model, which provided the framework for designing, implementing, and evaluating the intervention.

The researchers secured permission to administer a pen-and-paper one-group pre-test and post-test. The data collected provided valuable evidence on the effectiveness of the validated workbook as a supplemental learning resource. Descriptive statistics, specifically the mean and standard deviation, were employed to determine students' proficiency levels in the basic concepts of trigonometry before and after exposure to TRIBOO. To further establish the significance of observed differences, a paired t-test was conducted to compare pre-test and post-test scores, thereby assessing the impact of the intervention on student performance.

Findings

Table 1 presents the mean proficiency level of Grade 12 STEM students in the basic concepts of trigonometry, as measured by their pre-test scores.

Table 1

Mean level of students' proficiency on the basic concepts of trigonometry

Test	Mean	SD	Interpretation
Pre-Test	5.06	2.00	Poor
Post-test	10.00	1.55	Good

Legend: 13 – 15 Very Good; 10 – 12 Good; 7 – 9 Fair; 4 – 6 Poor; 0 – 3 Very Poor

In the pre-test, students obtained a mean score of 5.06 out of 15, indicating performance just above the midpoint. The standard deviation of 2.00 suggests moderate variability, with some students performing

significantly higher or lower than the average. Based on the predefined interpretation scale, this mean score falls within the poor category, confirming that Grade 12 STEM students demonstrated low proficiency in the basic concepts of trigonometry. Obeng et al. (2024) noted that trigonometry is often perceived as more abstract and challenging than other mathematical domains, largely because it requires students to connect geometric representations (e.g., triangles and diagrams) with numerical symbols and algebraic reasoning. Such abstraction can hinder conceptual understanding and lead to lower levels of achievement. Addressing this gap requires additional instructional support that bridges conceptual and procedural knowledge. Targeted interventions particularly the use of structured workbooks have been shown to enhance both proficiency and confidence in solving trigonometric problems. Inocencio and Calimlim (2021), for instance, reported that teacher-developed workbooks significantly improved student performance, underscoring their utility as instructional scaffolds.

In the post-test, students achieved a mean score of 10.00, categorized as good performance. The lower standard deviation of 1.55 indicates that scores were more tightly clustered around the mean, suggesting greater consistency across student outcomes. These findings demonstrate that, following the implementation of TRIBOO, students exhibited marked improvement in their proficiency in the basic concepts of trigonometry.

The positive learning gains may be attributed to the workbook's structured design, which provided learners with step-by-step guidance, diverse examples, and practice opportunities that reinforced conceptual clarity and problem-solving skills. Consistent with the findings of Collado and Abubo (2021), students who engaged with workbook-based instruction

outperformed those taught solely through traditional lecture methods. This highlights the value of integrating structured workbook exercises into trigonometry instruction, not only to improve student outcomes but also to promote deeper understanding and mastery of mathematical concepts.

Table 2

Test of significant difference between the pre-test and post-test results

Item	Mean	SD	Mean Difference	T-Test	Critical Value	Interpretation
Pre-Test	5.06	2.00				
			4.94	12.18	2.032	Significant
Post-Test	10.00	1.55				

Table 2 presents the difference between students' pre-test and post-test performance in the basic concepts of trigonometry. The analysis yielded a mean difference of 4.94 and a computed t-value of 12.18, which exceeds the critical t-value of 2.032 at the 0.05 level of significance. Consequently, the null hypothesis was rejected, indicating a statistically significant difference between pre-test and post-test results.

The post-test scores, which were substantially higher than the pre-test scores, provide clear evidence that the use of the TRIBOO workbook positively influenced students' proficiency in trigonometry. This finding aligns with Talas and Panoy (2023), who demonstrated that supplemental materials contribute to improvements in students' critical thinking skills, as reflected in significant pre- and post-test gains. Integrating such resources into instruction can therefore help learners strengthen their ability to analyze, evaluate, and synthesize information more effectively.

At the same time, Collado and Abubo (2021) emphasized that while workbook use enhances academic performance, its impact is maximized when paired with effective instructional strategies. This underscores the

pivotal role of teachers in facilitating workbook use not only by integrating the material into classroom practice but also by fostering a supportive and engaging learning environment. Thus, while TRIBOO proved effective as a supplemental resource, its success ultimately depends on thoughtful pedagogy and the quality of instructional delivery.

Table 3

Overall rating of the TRIBOO among the five expert validators

Criteria	Mean	SD	Interpretation
1. Workbook Objectives	3.92	0.28	Highly Acceptable
2. Workbook Content	3.64	0.49	Highly Acceptable
3. Workbook Format and Language	3.72	0.46	Highly Acceptable
4. Workbook Relevance	3.72	0.46	Highly Acceptable
Overall Weighted Mean	3.71	0.55	Highly Acceptable

Table 3 presents the overall ratings of TRIBOO as evaluated by five expert validators across four criteria: workbook objectives, content, format and language, and relevance. The workbook objectives obtained the highest mean rating of 3.92 with a standard deviation of 0.28, indicating strong clarity and alignment with intended learning outcomes. The content was rated with a mean of 3.64 (SD = 0.49), reflecting its adequacy in addressing the fundamental concepts of trigonometry. Meanwhile, both format and language and relevance received a mean of 3.72 with a standard deviation of 0.46, suggesting that the workbook was presented in an accessible manner and was considered highly pertinent to student learning needs.

All criteria were interpreted as "highly acceptable." The overall weighted mean of 3.71 (SD = 0.55) further supports this interpretation, indicating that the validators collectively found the TRIBOO workbook to be an effective and appropriate supplemental learning material for teaching

the basic concepts of trigonometry. These findings affirm that the workbook possesses both instructional value and practical applicability in enhancing student proficiency.

Recommendation

Students can utilize TRIBOO as an effective study tool to review fundamental concepts and engage in self-paced learning at their own convenience. For mathematics teachers, the validated workbook is recommended as a supplemental resource that can enhance instructional strategies and address diverse student learning needs. To maximize accessibility, it is further recommended that TRIBOO be made available online, enabling both students and teachers to benefit from greater flexibility and ease of use.

For future research, pilot testing TRIBOO with a larger and more diverse group of students is suggested to strengthen the evaluation of its effectiveness and determine its potential for wider implementation. Such initiatives will not only validate its broader applicability but also provide valuable insights into refining its content and delivery for greater impact in mathematics education.

Bibliography

Adawiyah, I., & Kurniasari, I. (2020). Profile of understanding students' mathematical concept on trigonometry based on Grasha Riechmann's learning style. *MATHEdunesa, 9*(1), 15–23. https://doi.org/10.26740/mathedunesa.v9n1.p15-23

Agbunag, M. R. (2022). Contextualized and localized supplementary e-learning materials in science 8 physics. *International Journal of Multidisciplinary: Applied Business and Education Research, 3*(11), 2378-2396. http://dx.doi.org/10.11594/ijmaber.03.11.22

Akouaydi, H., Hamdi, Y., Boubaker, H., Alaya Cheikh, F., & Alimi, A. M. (2021). Workbook for E-Education: Children's online handwriting quality analysis. *TechRxiv*. https://doi.org/10.36227/techrxiv.14005955

Alejandria, L. N., Bajenting, J. M. S., Pacatan, M. A. L. D., & Diquito, T. J. A. (2023). The use of educational board game as a supplemental tool in learning periodic table of elements among senior high school students. *American Journal of Education and Technology, 2*(1), 60–67. https://doi.org/10.54536/ajet.v2i1.1292

Araza, F., & Magnaye, L. J. (2023). Development and validation of Most Essential Learning Competency-based workbook in General Physics 1 for senior high school. *SEA-QIS Journal of Science Education, 3*(01), 1–13. https://doi.org/10.58249/sjse.v3i01.72

Arhin, J., & Hokor, E. K. (2021). Analysis of high school students' errors in solving trigonometry problems. *Journal of Mathematics and Science Teacher, 1*(1), em003. https://doi.org/10.29333/mathsciteacher/11076

Ayado, D. M., & Berame, J. S. (2022). Effectiveness of supplementary modular learning materials to grade 12 students in science, technology, engineering, mathematics track in stoichiometry. *International Journal of Recent Research in Thesis and Dissertation, 9*(4), 112–127.

Basilio, C. R., & Sigua, E. M. S. (2022). Development and validation of multimedia-based instructional module in Science 7. *International Research Journal of Science, Technology, Education, and Management, 2*(1), 152-162. https://doi.org/10.5281/zenodo.6496847

Batidor, P. G., & Casinillo, L. F. (2021). Evaluating spiral progression approach (SPA) in teaching science and mathematics for junior high curriculum. *Philippine Social Science Journal, 4*(3), 39-47. https://doi.org/10.52006/main.v4i3.362

Benitez, I. P. (2020). Development of workbook to enhance students'

competency in computer networking fundamentals. *International Journal of Educational Sciences, 31*(1–3). https://doi.org/10.31901/24566322.2020/31.1-3.1165

Bernido, R. (2020). Assessing students' performance in guided inquiry-based learning environment. *Educational Measurement and Evaluation Review, 11*, 25–44.

Besana, D. B., Bantulo, J. S., & Quines, L. (2022). Effectiveness of supplementary materials in Mathematics 3 in San Vicente Elementary School. *International Journal of Recent Research in Thesis and Dissertation, 3*(2), 110–130. https://doi.org/10.5281/zenodo.7082477

Besonia, B. E. A., Espora, S. M. H., Bernardez, M. F. M., & Galagala, M. R. G. (2023). Culturally relevant supplemental e-learning materials in teaching purposive communication. *TEM Journal, 12*(2), 634–639. https://doi.org/10.18421/tem122-06

Bordia, D. (2022). Advantages of workbooks. *Teachmint Blogs.* https://www.google.com/amp/s/blog.teachmint.com/advantages-of-workbooks/amp/

Carandang, E. S. P., Caguete, R. R., & Balmes, J. M. R. (2024). Attitude and challenges in learning mathematics in the modern world (MMW): Basis for intervention program. *International Journal of Mathematics and Mathematical Sciences, 6*(3), 85–99. https://doi.org/10.34104/ijmms.024.085099

Chi, C. (2023, December 6). Philippines still lags behind world in math, reading and science — PISA 2022. *Philstar.* https://www.philstar.com/headlines/2023/12/06/2316732/philippines-still-lags-behind-world-math-reading-and-science-pisa-2022

Collado, V. F., & Abubo, D. P. (2021). Comparison between the use of lecture and workbook in improving the academic performance of students in ecology. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12*(13), 4412–4421.

Comay-Ao, J. C., Mintac, P. O., & Turalba, M. A. (2021). Improving the basic mathematics operation skills of primary grade learners through Remediation, Reinforcement and Enhancement Model workbook. https://depedro1.com/wp-content/uploads/2019/02/Josielyn-Comay-ao.pdf

Cruz, L. I. C., & Rivera, K. C. (2021). Development and validation of project-based module for selected topics in biology. *International Journal of Educational Research and Social Sciences, 3*(3), 1124–1137. https://doi.org/10.51601/ijersc.v3i3.374

Decoriña, D. M. (2022). Supplementary learning resource package in

science 10 physics. *International Journal of Multidisciplinary: Applied Business and Education Research, 3*(11), 2362-2377. http://dx.doi.org/10.11594/ijmaber.03.11.21

dela Cruz, R. Z., & Hernandez, G. D. (2023). Challenges of public-school elementary mathematics teaching in the new normal. *Indonesian Journal of Social Sciences, 15*(1), 8–20. https://doi.org/10.20473/ijss.v15i1.40340

Delima, C. M. (2022). The efficiency of hand tricks in learning trigonometric ratios. *International Journal of Multidisciplinary: Applied Business and Education Research, 3*(12), 2692–2698. https://doi.org/10.11594/ijmaber.03.12.21

Dominado, N., Bulaun, C. M., & Quiambao, C. G. (2023). Development and validation of an interactive e-book in physics 9. *International Journal of Multidisciplinary: Applied Business and Education Research, 4*(8), 2706–2715. https://doi.org/10.11594/ijmaber.04.08.03

Fran, F. A. (2022). Development and validation of competency-based Research I workbook for distance learning. *International Journal of Education and Learning, 4*(1), 81–88. https://doi.org/10.31763/ijele.v4i1.615

Greubel, A., Wenkmann, J., Siller, H., & Hennecke, M. (2023). Teaching reflective use of technology: A piloted workbook based on evacuations. *Proceedings of the 20th International Conference on Cognition and Exploratory Learning in Digital Age*.

Gyamfi, A. (2021). Effectiveness of workbooks in the teaching and learning process. *Kwadwoan Publishing*.

Haryani, D., Subagjo, A., Hamdani, M., Ali Hasan, Q., & Widyanti, N. (2022). Analysis of the difficulties of class X students of SMKN 4 Palangka Raya in solving trigonometry problems. *Jurnal Pendidikan, 23*(1), 30–39. https://doi.org/10.52850/jpn.v23i1.4667

Homillano, L. B. (2023). Development and validation of an instructional module in science, technology, and society (STS) in the tertiary education curriculum. *Asian Journal of Education and Social Studies, 46*(3), 41–52. https://doi.org/10.9734/ajess/2023/v46i31005

Ibañez, E. D., Subia, G. S., Medrano-Allas, S., Mendoza, J. I., & Mina, J. C. (2021). Modern mathematics applications: Solutions to challenges encountered in teaching spiral progression in Mathematics 7. *Open Access Library Journal, 8*, 1–7. https://doi.org/10.4236/oalib.1107623

Ignacio, A. A., & Bajet, A. P. (2025). Assessing the implementation of

senior high school mathematics curriculum: Teachers' and students' perceptions in Calbayog City Division, Philippines. *European Journal of Education and Pedagogy, 6*(1), 61–65. https://doi.org/10.24018/ejedu.2025.6.1.918

Inocencio, B. T., & Calimlim, A. C. (2021). Development and validation of teacher-made science workbook of grade 8 students in the Philippines. *International Journal of Multidisciplinary: Applied Business and Education Research, 2*(10), 858-869. http://dx.doi.org/10.11594/ijmaber.02.10.02

Isa Irawan, M., Mukhlash, I., Adzkiya, D., Darmadi, & Sanusi. (2019). Development of trigonometric visualization concepts to increase the study motivations of SMK students. *Journal of Physics: Conference Series, 1218*(1), 012049. https://doi.org/10.1088/1742-6596/1218/1/012049

Ishtiaq, M. (2019). Book review: Creswell, J. W. (2014). *Research design: Qualitative, quantitative and mixed methods approaches* (4th ed.). Thousand Oaks, CA: Sage. *English Language Teaching, 12*(5), 40. https://doi.org/10.5539/elt.v12n5p40

Jaudinez, A. S. (2019). Teaching senior high school mathematics: Problems and interventions. *Pedagogical Research, 4*(2), em0031. https://doi.org/10.29333/pr/5779

Jelatu, S., Kurniawan, Y., Kurnila, V. S., Mandur, K., & Jundu, R. (2019). Collaboration TPS learning model and M-learning based on Android for understanding of trigonometry concepts with different cognitive style. *International Journal of Instruction, 12*(4), 545–560. https://doi.org/10.29333/iji.2019.12435a

Lacea, J. P., & Buscano, J. D. (2023). Development and validation of learning activity sheets in rational expressions and linear equations and inequalities. *International Journal of Multidisciplinary: Applied Business and Education Research, 4*(5), 1494-1502. https://doi.org/10.11594/ijmaber.04.05.11

Lomibao, L. S. (2016). Enhancing mathematics teachers' quality through lesson study. *SpringerPlus, 5*, 1590. https://doi.org/10.1186/s40064-016-3215-0

Magayon, V. C., & Tan, E. B. (2016). Learning mathematics and differentiated instruction in the Philippines: A phenomenographical study on struggles and successes of Grade 7 students. *International Journal of Educational Studies in Mathematics, 3*(3), 1–14.

Maghirang, S. M., & Banzon, J. P. (2023). Analysis of the factors affecting low performance of senior high school students in Integrated Science. *European Journal of Education Studies, 9*(10).

https://doi.org/10.46827/ejes.v9i10.4492

Malicoban, E. V., Buco, I. M. S., Yaun, D. A. A., Mordeno, I. C. V., & Lasta, N. A. Y. (2021). Development of a supplementary material on modes of heat transfer for STEM learning among Grade 7 students. *Journal of Physics: Conference Series, 1835*, 012032. https://doi.org/10.1088/1742-6596/1835/1/012032

Manzano, E. C. (2023). Validation of instructional module in selected topics in Science, Technology and Society (STS) course. *Psychology and Education: A Multidisciplinary Journal,* 7, 106-111. https://doi.org/10.5281/zenodo.7644662

Mocorro, R.E. & Mocorro, D.R. (2025). Social justice in mathematics classes: A case in a university in the Philippines. *Journal for Multicultural Education.* https://doi.org/10.1108/JME-02-2025-0053

Nanmumpuni, H. P., & Retnawati, H. (2021, February 1). Analysis of senior high school student's difficulty in resolving trigonometry conceptual problems. *Journal of Physics: Conference Series.* https://iopscience.iop.org/article/10.1088/1742-6596/1776/1/012012

Navarra, R., Pallado, C. R., & Tenedero, C. (2022). The effectiveness of the Technical Vocational Education and Training's (TVET) flexible learning delivery in the selected TESDA technology institutions in National Capital Region. *Psychology and Education: A Multidisciplinary Journal.* https://ejournals.ph/article.php?id=20589

Nurmeidina, R., & Rafidiyah, D. (2019). Analysis of students' difficulties in solving trigonometry. *Proceedings of the 4th Progressive and Fun Education International Conference.* http://dx.doi.org/10.4108/eai.7-8-2019.2288422

Obeng, B. A., Banson, G. M., Owusu, E., & Owusu, R. (2024). Analysis of senior high school students' errors in solving trigonometry. *Cogent Education*, 11(1). https://doi.org/10.1080/2331186X.2024.2385119

Padernal, R. E., & Diego, C. V. (2020). Academic performance of senior high school students in pre-calculus. *Philippine Social Science Journal, 3*(2), 69–70. https://doi.org/10.52006/main.v3i2.185

Perkins, N., Davies, G., & Baker, I. (2023). Creation of a physiotherapy student workbook. *Poster Presentations.* https://doi.org/10.1136/spcare-2023-pcc.47

Rahayu, A., Ilimu, E., & Adewia, M. (2022). Development of interactive E-Workbook based on peer-led team learning on collaboration skills and critical thinking in basic chemistry concept. *Jurnal Tadris*

Kimiya, 7(2), 201–214. https://doi.org/10.15575/jtk.v7i2.19750

Rahayu, G., & Rosjanuardi, R. (2022). Students' epistemological obstacles on analytic trigonometry. *AIP Conference Proceedings, 2597*, 070037. https://doi.org/10.1063/5.0102638

Rivera, G. I. (2023). Experiences and effect of using a developed workbook on the proficiency level of Grade 7 students in word problems involving linear equations in one unknown. *International Journal of Social Science and Human Research, 6*(5), 2558–2563. https://doi.org/10.47191/ijsshr/v6-i5-05

Rogayan, D. V., & Dollete, L. F. (2019). Development and validation of physical science workbook for senior high school. *Science Education International, 30*(4), 284–290. https://doi.org/10.33828/sei.v30.i4.5

Rohimah, S. M., & Prabawanto, S. (2019). Student's difficulty identification in completing the problem of equation and trigonometry identities. *International Journal of Trends in Mathematics Education, 2*(1), 34–36. https://doi.org/10.33122/ijtmer.v2i1.50

Saldo, I. J. P., & Walag, A. M. P. (2023). Development and acceptability of chemistry lessons integrating [title truncated]. *Journal of Innovations in Teaching and Learning, 3*(1), 28-34. https://doi.org/10.12691/jitl-3-1-6

Sulistina, O., & Salimaturosidah, R. (2023). Development of senior high school students' workbook "Redox and Electrochemistry" using SSI as a context in inquiry-based learning. *AIP Conference Proceedings.* https://doi.org/10.1063/5.0112215

Taherdoost, H. (2022). Designing a questionnaire for a research paper: A comprehensive guide to design and develop an effective questionnaire. *Asian Journal of Managerial Science, 11*(1), 8–16. https://doi.org/10.51983/ajms-2022.11.1.3087

Talas, M., & Panoy, J. F. D. (2023). Development of learning mode-based supplemental material for enhancing critical thinking abilities in Grade 10 biology. *International Journal of Social Science Humanity and Management Research, 2*(9). https://doi.org/10.58806/ijsshmr.2023.v2i9n09

Utami, C. A., Nopita, D., & Subroto, G. (2023). Designing interactive workbook via Liveworksheets for reading skill at grade 10. *Journal of Language, Literature, and English Teaching (JULIET), 4*(1), 10–18. https://doi.org/10.31629/juliet.v4i1.4866

Valle, L. (2024). Reimagining mathematics education: Identifying training needs and challenges among public elementary school teachers post-

pandemic. *International Journal of Education and Practice, 12*(3), 527–539. https://doi.org/10.18488/61.v12i3.3723

Vistro-Yu, C. P., Hao, L. C., & Helton Sua, M. (2025). The struggle is real: Finding opportunities for problem posing in the Philippine school mathematics curriculum. *Asian Journal for Mathematics Education, 4*(2), 280–294. https://doi.org/10.1177/27527263251340036

Yeh, C. Y. C., Cheng, H. N. H., & Chen, Z. H. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning, 14*, 5. https://doi.org/10.1186/s41039-019-0100-9

Zulfa, H., Saputro, D. R., & Riyadi. (2019). Students' difficulties in mathematics learning with artisan character type in HOTS trigonometry test. *Journal of Physics: Conference Series, 1321*(2), 022104. https://doi.org/10.1088/1742-6596/1321/2/022104