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Contextualizing Pisa Mathematical Problems: Development and Validation

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Abstract— *This study specifically examines the problem-solving techniques employed by students in contextualized PISA mathematical problems, providing insight into their unique strategies and reasoning processes. The researcher employed a mixed-methods approach that included both qualitative and quantitative research methods. The sample respondents are grade 8 students aged 14-15 years old from Laboratory High School in Northern Mindanao, Philippines.. This study investigates the problem-solving techniques used by students when tackling contextualized PISA mathematical problems. [1] It aims to understand students' unique strategies and reasoning processes in these scenarios and how they adapt their mathematical thinking to real-world situations. [1.] The findings will contribute to a better understanding of how students adapt their mathematical thinking to the real world.*

Keywords— *Contextualized Pisa Mathematical Items, Mathematics Education, Problem Solving.*

I. Introduction

Problem-solving is a crucial skill that involves applying mathematical knowledge and abilities at an advanced level [1]. It is essential for students as they transition into life after graduation [2]. This skill is one of the key competencies targeted for development during basic education. Verbal problems play a significant role in enhancing problem-solving abilities, as they require students to utilize and expand their existing mathematical understanding [3]. As the demand for higher-order thinking skills continues to rise, the ability to tackle complex, unfamiliar problems has become increasingly vital [4].

Problem-solving process is described as a complex procedure that requires the integration of multiple skills. This process involves several key elements: understanding the problem, selecting the relevant information from the given data, translating the obtained information into mathematical symbols, and arriving at a solution through the necessary calculations. These steps do not follow a strictly linear sequence [5]. The initial and most critical phase of problem-solving is comprehending the given information. If this step is not successfully completed, individuals may produce meaningless results by randomly using the numbers provided in the problem [6];[7];[8].

Contextualizing PISA mathematical problems refers to the process of adapting these problems to align with students' local experiences, cultures, and prior knowledge, making them more relatable and comprehensible [9]. Studies suggest that when mathematical problems are framed within familiar contexts, students demonstrate improved engagement and problem-solving performance [10]. Furthermore, problem-solving techniques, such as Polya's four-step method—understanding the problem, devising a plan, carrying out the plan, and looking back— are crucial in developing students' mathematical reasonin [11]. Investigating how students approach and solve contextualized PISA problems provides insights into their cognitive processes, difficulties, and potential strategies for improving mathematical instruction.

II. Methods

This study employs a mixed-methods research design, integrating quantitative and qualitative approaches. The quantitative aspect focuses on modifying and validating contextualized PISA mathematical problems and assessing students' performance, while the qualitative component investigates students' problem-solving processes [12]. This approach ensures a comprehensive understanding of how students engage with PISA-based problems, aligning with studies emphasizing the importance of both statistical data and in-depth cognitive analysis [14].

The participants of this study are 32 grade 8 students in one of the secondary schools in Lanao Del Norte during the school-year 2024-2025. The study employed purposive sampling, a non-random technique where participants, including a mathematics teacher and students, were specifically chosen because they possessed characteristics relevant to the research objectives and were available for the study's duration. This method allowed for the selection of individuals capable of providing rich insights into the research topic.

The research process began by securing ethical approval. Following this, the research instruments, which included contextualized math problems and interview questions, underwent a validation process involving mathematics teachers and English teachers. Subsequently, these problems were pilot-tested with a group of grade 9 students, and based on their performance, the problems were refined. The finalized problems were then administered to the grade 8 participants within a single class period. After the test, the students' responses were analyzed, and participants were grouped based on their performance. Finally, follow-up interviews were conducted with students from each performance group to gather detailed accounts of their experiences during the test.

Ultimately, the study aimed to gain a deeper understanding of the current state of mathematics learning and teaching. The broader goal was to identify ways to make mathematics education more effective and less challenging for both students and teachers.

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III. Result and Discussion

The researcher developed a set of contextualized PISA math problems that aligned with the objective of investigating how students approach real-world mathematical tasks. These were designed to reflect situations that are culturally and experientially familiar to Filipino students. Contextualization was essential in ensuring that the problems would not only assess mathematical literacy but also resonate with students' lived realities. The development of the problems was guided by the PISA mathematical literacy framework, particularly focusing on three processes: formulating, employing, and interpreting mathematics in real- world contexts. The tasks were designed to target the problem- solving domain of PISA. This emphasized authentic scenarios that demand reasoning and decision-making. Original PISA- style problems were modified to include familiar settings such as local financial practices and economic conditions, transport routines, environmental and agricultural contexts and cultural references. Currency values were converted to Philippine pesos, and names, places, and activities were adjusted to reflect everyday Filipino life. These modifications ensured that students would find the tasks relatable and meaningful. A total of six scenarios were considered in the study where some scenarios had two or three problems. In total, there are 16 problems that were contextualized that focuses primarily on real-world application tasks categorized under PISA's problem-solving domain. Each problem was carefully reviewed to align with the learning competencies in the secondary level of Mathematics Curriculum under the K–12 framework. While the structure followed PISA's international assessment standards, the content was mapped to local curriculum expectations to ensure appropriateness for the target learners. In summary, the development process combined the structure of the PISA problem-solving framework with culturally relevant content derived from Filipino students' everyday experiences. This allowed for the creation of test items that not only evaluated mathematical thinking but also examined how students engage with mathematics when it is embedded in situations they can personally relate to. This contextualization process was integral to the study's aim of understanding students' problem-solving techniques in realistic and localized mathematical scenarios.

The contextualized PISA Math problem test underwent face validation using a structured rubric evaluated by two expert validators. Each item was rated across multiple criteria using a 4-point Likert scale. The inter-rater reliability was assessed using percent agreement and Cohen's Kappa. As observed in all 15 criteria, the two raters showed 100% agreement, with identical scores assigned for each item (13 items rated 4, and 2 items rated 3 by both). This yielded a percent agreement of 100% and a Cohen's Kappa coefficient of 1.0. This results indicates a perfect inter-rater reliability. This means that the rubric used was clear, objective, and consistently interpreted by the evaluators. This suggests that the contextualized PISA math problems were evaluated with a high degree of consistency and credibility. These results confirm that the evaluation instrument was consistently interpreted by both raters, strengthening the validity of the face validation process.

Cronbach's Alpha was used in a pilot study to evaluate the Contextualized PISA Math Problem instrument's internal consistency. This is a common way to assess a test's internal consistency or reliability. As shown in Table 4.1.2, the computed Cronbach's Alpha value is 0.84, with a 95% confidence interval ranging from 0.77 to 0.91.

According to [15] a Cronbach's Alpha coefficient of 0.70 and above is generally considered good, while values above 0.90 are regarded as excellent. The obtained alpha value of 0.84 which indicates a high level of reliability. This suggests that the test items in the contextualized PISA mathematics problem set are internally consistent and measure the same underlying construct—in this case, mathematical problem-solving skills in real-world contexts.

One of the problem retained was, problem 1: Buying a Motorcycle on Installment

Mark is a delivery rider in Cebu who wants to improve his livelihood by buying a brand- new motorcycle. The motorcycle costs ₱85,000 if paid in full. However, Mark does not have enough savings, so he is considering buying it on an installment plan from a dealership.

The dealership offers two payment options:

- Full Payment: ₱85,000 (one-time payment)
- Installment Plan:

Down payment: ₱20,000
Monthly payment: ₱3,500 per month for 2 years

Questions:

1. How much will Mark pay in total if he chooses the installment plan?
2. How much more does he pay compared to the full payment option?
3. If Mark earns an average of ₱18,000 per month, what percentage of his monthly income will go to his motorcycle payment under the installment plan?

This problem scored high during the pilot testing and most of pilot testing respondents got the high score in this. On the other hand, problem 8: Braking.

The approximate distance to stop a moving vehicle is the sum of:

- The distance traveled between the time the driver starts applying the brakes (reaction time distance)
- the distance travelled while the brakes are applied (braking distance)

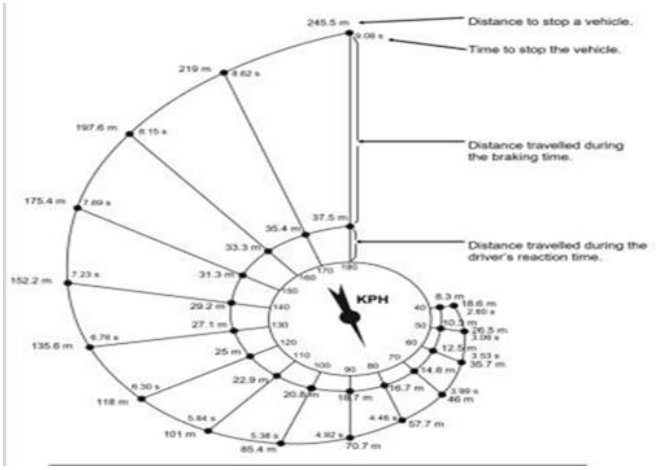
The 'snail' chart below illustrates the theoretical stopping distance for a car under ideal braking circumstances (a dry road with a nice surface, a very aware driver, and faultless brakes and tires) as well as the correlation between speed and stopping distance.

Questions:

1. If a vehicle is traveling at 110 kph, what distance does the vehicle travel during the driver's reaction time?
2. If a vehicle is traveling at 110 kph, how long does it take to stop the vehicle completely?
3. At a total distance of 70.7 meters, a second driver, who is driving in favorable weather, brings her car to a halt. Before the brakes were applied, what was the car's speed?.

Is one of the problems that is rejected because none of the pilot testing respondents got the right answer on this. This item got 0 average which means it should not be implemented or

should be rejected.



The contextualized PISA problems were scored using a five-point rubric: a score of 4 (Capstone) indicates that all indicators were observed in the student's solution; 3 and 2 (Milestone) reflect that most or some indicators were observed, respectively; 1 (Benchmark) suggests minimal understanding; and 0 (Wrong Answer) represents a complete lack of understanding or an incorrect solution. The mean score per item provides insight into the overall difficulty and accessibility of each problem.

Analysis of the results reveals that several items were generally well-understood by students. Notably, Problem 10 achieved the highest mean score of 3.20. This indicates that the majority of students were able to provide high-quality responses demonstrating complete understanding. Similarly, Problem 5 (mean = 3.13), Problem 1 (mean = 2.67), and Problem 17 (mean = 3.00) also reflected strong performance, with most students reaching the capstone level. These problems likely featured familiar and relevant contexts resonated with the students and facilitated comprehension.

Moderately challenging problems included Problems 3, 4, 6, 12, and 26, with mean scores ranging from 2.10 to 2.30. The contextualized PISA math problems presented require students to apply mathematical concepts to real-world scenarios, demanding not only computational skills but also the ability to interpret context, identify relevant information, and select appropriate mathematical operations. These types of problems often pose challenges for students due to their multi-step nature, the need for strong reading comprehension to extract necessary details, and the application of abstract mathematical concepts in practical situations. Students might struggle with translating word problems into mathematical expressions, identifying all the required information (sometimes even recognizing missing information), and justifying their answers with logical reasoning. Furthermore, interpreting visual data like graphs, as seen in one of the problems, adds another layer of complexity. .These items were partially completed by many students and frequently scored in the milestone range. This suggests that while students grasped the general idea, some struggled to fully demonstrate all indicators, possibly due to multi-step requirements or more complex data interpretation. These items appear to have balanced challenge and accessibility.

Conversely, several items were perceived as difficult, evidenced by lower average scores. Problems such as 7 (mean = 1.37), 8 (1.30), 13 (1.80), 14 (1.47), and 27 (1.83) show a concentration of benchmark and wrong-answer responses. The contexts in these problems may have been more abstract, unfamiliar, or required reasoning beyond students' current ability, thereby hindering performance. This problems involve applying mathematical concepts to real-world scenarios. Problem 7 and 8 focused on spatial reasoning and volume calculations, including optimization if students need to figure out the most efficient way to pack boxes. Problems 13 and 14 involve using a given formula to calculate a value and then rearranging the formula to find a different unknown, which tests algebraic manipulation skills within a scientific context. Lastly, problem 27 is a multi-step currency conversion problem that requires understanding exchange rates and performing sequential calculations.

A few problems emerged as extremely difficult or possibly flawed. Problems 20 and 21 had a mean score of 0.00, indicating that none of the respondents provided a correct or partially correct answer. Likewise, Problems 22, 15, 24, and 25 scored below 1.00, revealing that most students left them unanswered or provided incorrect responses. These results suggest potential issues in item construction that warrant careful revision or removal.

To select which problems will be used for the implementation, only those problems with majority in the capstone category and on its sub problem were considered. The items who meets these conditions were Item 1, 2, 3, 4, 6, 10, 12, 17 and 26. These items were about installment plans, exchange rates, percentage and interpreting data from table. Students find these problems easy to solve and relate to real-world application. However, out of these 9 items, only the top 6 were selected for the implementation.

IV. Conclusion and Recommendation

This study investigated the performance and experiences of students in solving contextualized PISA Math problems. A mixed quantitative and qualitative research design is employed in the study. A set of contextualized PISA math problems that investigates how students approach real- world mathematical tasks were developed with the guided from the PISA mathematical literacy framework. The development process combined the structure of the PISA problem-solving framework with culturally relevant content derived from Filipino students' everyday experiences. The created test questions not only checked students' math skills but also showed how they solve problems when the math is connected to real-life situations they can relate to.

A total of 16 contextualized PISA Math problems were developed across six real-world scenarios. These tasks were aligned with the PISA mathematical literacy framework, emphasizing formulation, application, and interpretation of mathematics in authentic contexts. Face validation by two expert raters showed perfect agreement (Cohen's Kappa = 1.0) which indicates high content validity. The Cronbach's Alpha from the pilot testing was 0.84, indicating that the instrument

had a high degree of internal consistency and confirming its reliability.

In addition, the researcher would like to recommend the following:

1. For students, it is recommended that they actively engage with contextualized mathematical problems, practice applying mathematical concepts to real- world situations, and seek additional help or resources when challenges arise to strengthen their problem-solving skills.
2. For teachers, it is advised to consistently integrate contextualized problems into classroom instruction, use real-life examples to illustrate mathematical concepts, and provide structured support to develop students' analytical and critical thinking abilities.
3. For school administrators, it is recommended to promote and support professional development programs focused on contextualized teaching strategies and to encourage a curriculum that emphasizes real-world application of mathematical knowledge.
4. For curriculum developers, it is essential to design learning materials and activities that feature authentic, real-world contexts, ensuring that the mathematics curriculum aligns with students' everyday experiences and future career needs.
5. For future researchers, it is recommended to explore further the factors influencing students' problem-solving abilities in different contexts and to investigate innovative strategies that can better bridge the gap between mathematical theory and real-world application.

REFERENCES

[1] Cai, J., & Lester, F. (2010). Why is teaching with problem solving important to student learning. *National council of teachers of mathematics*, *13*(12), 1-6.

[2] Krulik, S., & Rudnick, J. A. (1996). The new sourcebook for teaching reasoning and problem solving in junior and senior high school. *(No Title)*.

[3] Wyndhamn, J., & Säljö, R. (1997). Word problems and mathematical reasoning—a study of children's mastery of reference and meaning in textual realities. *Learning and instruction*, *7*(4), 361-382.

[4] Edwards, L. A. (2019). *Education, Technology and Higher Order Thinking* (Doctoral dissertation, La Trobe).

[5] Olkun, S., & Toluk, Z. (2004). Teacher Questioning with an Appropriate Manipulative May Make a Big Difference. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, *2*.

[6] Artzt, A. F., & Armour-Thomas, E. (2001). Mathematics teaching as problem solving: A framework for studying teacher metacognition underlying instructional practice in mathematics. In *Metacognition in learning and instruction: Theory, research and practice* (pp. 127-148). Dordrecht: Springer Netherlands.

[7] Goos, M., Galbraith, P., & Renshaw, P. (2000). A money problem: A source of insight into problem solving action. *International Journal for Mathematics Teaching and Learning*, 1-21.

[8] Carifio, J. (2015). Updating, modernizing, and testing Polya's theory of [mathematical] problem solving in terms of current cognitive, affective, and information processing theories of learning, emotions, and complex performances. *Journal of Education and Human Development*, *4*(3), 105-117.

[9] De Lange, J. (2007). *Mathematics for literacy*. In B. L. Madison & L. A. Steen (Eds.), *Quantitative literacy: Why numeracy matters for schools and colleges* (pp. 75-89). National Council on Education and the Disciplines.

[10] Wijaya, A. (2017). The relationship between students' errors in solving PISA mathematics tasks and reading difficulties. Journal of Mathematics Education, 8(1), 25- 40.

[11] Polya, G. (1945). How to solve it: A new aspect of mathematical method. Princeton University Press.

[12] Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research*. Sage Publications.

[13] Patton, M. Q. (2015). Qualitative research & evaluation methods: Integrating theory and practice. Sage Publications.

[14] Güngör, B. A., Metin, M., & Saraçoglu, S. (2022). A Content Analysis Study towards Researches Regarding Context-Based Learning Approach in Science Education by between Years 2010 and 2020 in Turkey. *Journal of Science Learning*, *5*(1), 69-78.

[15] George, D., & Mallery, P. (2024). *IBM SPSS statistics 29 step by step: A simple guide and reference*. Routledge.