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## Alignment of the Philippine Mathematics Teacher Education Curriculum with the Programme for International Student Assessment

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**Abstract:** This study aimed to examine the alignment of the Philippine mathematics teacher education curriculum with the 2021 mathematics literacy framework of the Programme for International Student Assessment (PISA). Such study could inform the Philippine Commission on Higher Education (CHED) if its mandated bachelor's degree in secondary education major in mathematics could produce teachers at the secondary level prepared to deliver the expectations of PISA to mathematically literate 15-year-old learners. Through document analysis, the researcher reviewed the alignment of two official documents accessible online: the 2017 Philippine mathematics teacher education curriculum and the 2021 PISA mathematics literacy framework. Three mathematics education experts validated the researcher's analysis. The results revealed alignment of the content and competencies covered by the teacher education curriculum and PISA mathematics literacy framework. However, the researcher found gaps in the curriculum in terms of its responsiveness in capturing some contexts and 21st century skills emphasized in PISA 2021 mathematics literacy framework. The study provided recommendations in addressing the gaps to inform needed updating in the teacher education curriculum to meet the expectations of PISA as a step to meeting the international standards of quality educational program.

**Keywords:** *Alignment, international student assessment, mathematics teacher education, national curriculum, Programme for International Student Assessment.*

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### Introduction

The quality of basic education in the Philippines has been the focus of academic discourse since the release of the 2018 Programme for International Student Assessment (PISA) results in December 2019. The dismal results triggered the Department of Education (DepEd) to launch its reform program called "*Sulong Edukalidad*" to mean moving forward to improving the quality of basic education in the country (DepEd, 2019b). This battlecry for quality basic education demands curriculum update and review, improvement of the learning environment, teachers' upskilling and retooling, and engagement of stakeholders for support and collaboration.

As teachers play a significant role in the movement for quality education, the Teacher Education Institutions (TEIs), being the producer of teachers in the country, should respond to this battlecry of DepEd. The TEIs should train teachers to meet the quality standards desired by the K to 12 program. They need to be equipped with the content knowledge and pedagogy to be effective producers of globally competitive Filipino learners who are holistically developed and equipped with 21st century skills (Republic of the Philippines, 2013).

In addressing this need, the teacher education programs should support the attainment of the standards set in PISA and other international large-scale assessments (ILSAs) to inform the effectiveness of the K to 12 program implemented since 2013 (DepEd, 2017; DepEd, 2019a). As indicated in the Republic Act (RA) 10533 or known as Enhanced Basic Education Act in 2013, the country has to continuously gather indicators of the effectiveness of the Enhanced Basic Education Program. The law mandates DepEd to allocate funds to immediately attain international quality benchmarks (Republic

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of the Philippines, 2013; DepEd, 2013). This provision in the law explains DepEd's commitment to participate again in ILSAs, including the PISA in 2021 (DepEd, 2019b). RA10533 further states that every student should have an opportunity to receive a globally competitive quality education based on a pedagogically sound curriculum that is at par with international standards. This law supports the declaration in the 1987 Philippine constitution for the State to "protect and promote the right of all citizens to quality education at all levels, and shall take appropriate steps to make such education accessible to all" (Republic of the Philippines, 1987, Article XIV Section 1). The reform is consistent with quality education set in the Sustainable Development Goals (SDG) 4.0 (UNDP, 2021). Education for Sustainable Development (ESD), an integral component of SDG 4.0, emphasizes the contribution of learning content to the survival and prosperity of humanity (UNESCO, 2019).

As student assessment is essential in gathering evidence of the effectiveness of the quality reform programs in education, its framework could be a good reference for curriculum review and improvement. ILSA frameworks like those from PISA, Trends in International Mathematics and Science Survey (TIMSS), and the Southeast Asia Primary Learning Metrics (SEA-PLM) are suitable bases in reviewing the Kto12 Curriculum. In reviewing the Junior High School (JHS) curriculum, however, the PISA framework is the most appropriate reference for educational policy and curriculum review because of its comprehensiveness and reliability in providing indicators of students' capabilities (Schleicher, 2019). Moreover, based on the OECD Report of PISA 2018, sampled 15-year-old learners were in their Grade 9 to 11 although majority were in Grade 10 in the secondary education program (OECD, 2019a). For the Philippines, however, the modal grade was Grade 9 (OECD, 2019a). This would mean that most 15-year old Filipino learners are in their Grade 9 of the JHS curriculum.

Studies had revealed gaps in the Philippine Kto12 Curriculum when mapped with ILSA frameworks (Balagtas, 2020; Balagtas et al., 2020; Balagtas & Montealegre, 2020). The identified gaps could explain why in all areas assessed in ILSAs in 2018 and 2019 (i.e., PISA, TIMSS, SEA-PLM), the Filipino learners consistently performed below the international benchmarks (DepEd, 2019b; Mullis et al., 2020; DepEd et al., 2021). However, no study has examined if ILSA frameworks are aligned with the Philippine teacher education program to know if would-be teachers are trained to deliver the content and competencies targeted in ILSAs among their future students. Since the Commission on Higher Education (CHED) mandates the TEIs' curriculum, so any call for its review should start with it.

In 2017, CHED released its policies, standards, and guidelines (PSGs) in the implementation of the Bachelor in Secondary Education (BSEd). This degree program set in CHED Memorandum Order (CMO) no. 75 series of 2017 defines the program outcomes, performance indicators, and course offerings of each specialization program. In addition, the Philippines Qualifications Framework (PQF), the Philippine Professional Standards for Teachers (PPST), the Kto12 Program, and other relevant documents shaped the BSEd program (CHED, 2017).

One BSEd specialization area is mathematics. The BSEd major in mathematics program should be examined, as mathematics is a common assessment area in all ILSAs that the Philippines has participated in, where Filipino learners consistently performed low. The BSEd mathematics program expects would-be mathematics teachers to demonstrate the general and discipline-specific program outcomes and performance indicators of highly qualified mathematics teachers in secondary schools through their specialization courses. The BSEd mathematics program should produce teachers with high mathematics literacy.

The Organization for Economic Co-operation and Development (OECD), the organization that started PISA in 2000 for 15-year-old learners, defines mathematics literacy as:

Mathematical literacy is an individual's capacity to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world contexts. It includes concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals to know the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged, and reflective 21st century citizens. (OECD, 2018, p.7)

PISA covers four dimensions in assessing mathematics literacy: core mathematical skills, content domain, context domain, and 21st century skills. The *first dimension* covers the two *core mathematical competencies* of reasoning and problem-solving. Mathematical reasoning refers to one's ability to present reasons or arguments convincingly or to draw impartial conclusions without the need for external validation (OECD, 2018). Mathematics reasoning involves three problem-solving processes: formulating; employing; and interpreting and evaluating (OECD, 2018). The *second dimension* is the *content domain* with four categories: change and relationships; space and shape; quantity; and uncertainty and data. The *third dimension* is the *context domain*. Context is where the problems that need mathematical content knowledge and skills are applied. In PISA 2021, their application is in a wide variety of real-life contexts: personal, occupational, societal, and scientific (OECD, 2018). The *last dimension* covers the *21st century skills*: creativity; research and inquiry; self-direction, initiative, and persistence; information use; systems thinking; communication; and reflection (OECD, 2018). These skills, which are both an outcome of and focus for mathematics, are expected to be infused in mathematics teaching for the students to make independent judgments and take responsibility for them (OECD, 2018).

The PISA mathematics literacy items are designed in units with reference to the same stimulus material that is usually reflective of the context domain (personal, occupational, societal, and scientific) where the two core mathematical thinking skills (reasoning and problem solving) are assessed using the content domain (change and relationships, space and shape, quantity, uncertainty and data) that 15-year-old learners are expected to acquire. The assessment is computer-based using multiple-choice and constructed-response test formats (OECD, 2018).

To know if the CHED-mandated program for mathematics teachers aligns with the PISA 2021 mathematics literacy framework, which is unavailable in the literature review, this study was conducted. The general and specific program outcomes and performance indicators, as well as the mandated courses for the BSEd Major in Mathematics, were examined if aligned with the processes, content, context, and 21st century skills emphasized in the PISA 2021 mathematics framework. In particular, the study sought answers to the question, "How aligned are the program outcomes, performance indicators, and courses in the BSEd Major in Mathematics program defined in CHED Memo No. 75. Series of 2017 to PISA 2021 mathematics literacy in terms of a) Core Competencies; b) Content Domain; c) Context Domain; and d) 21st century skills?". The results of such analysis were the basis for recommending improvements to the program to meet the quality demands of PISA 2021 Mathematics Literacy should there be gaps found.

## Methodology

### *Research Design*

The study is a qualitative-descriptive research that used document and content analysis to describe the alignment of the Philippine teacher education program for mathematics teachers in secondary schools with the PISA 2021 Mathematics Literacy Framework. The analysis made use of the official documents available on websites of OECD and CHED.

### *Sample and Data Collection*

The researcher performed the document analysis as a product of her sabbatical leave. However, to ensure the acceptability of the process and outcome of her study, she selected purposively the professional expertise of three mathematics educators with a doctorate degree and with 14 to 37 years of teaching experience in the University as peer reviewers. These reviewers conducted a similar study where they examined the alignment of the Philippine Kto12 curriculum vis-à-vis the PISA 2021 mathematics framework.

The researcher prepared a *document analysis matrix* that has the critical components of the PSGs for the BSEd Major in Mathematics Curriculum and PISA 2021 Mathematics Literacy Framework in performing the document analysis. In addition, she used number and color codes to indicate the common areas of explicit alignment between the two documents analyzed. A hired professional licensed teacher reviewed the matrix to ensure that all the critical components in the documents for review were present and correctly captured. The researcher also prepared a *validation instrument* that the peer reviewers used in the review of her document analysis.

The study underwent three stages: Pre-document analysis, actual document analysis, and post-document analysis. The *pre-document analysis* includes securing the approval of the Research Ethics Committee to conduct the study. After getting the Committee's approval to proceed, she collected the targeted official documents from OECD and CHED websites, identified the components for analysis, and prepared the tool for document analysis. *Actual document analysis* refers to the mapping of the common features of the two official documents. Finally, *Post-data analysis* includes the validation and finalization of the document analysis and the identification of gaps in the BSEd Major in Mathematics program based on the PISA frameworks and how to address them.

### *Data Analysis*

As the data are primarily qualitative with the mapping of the common information in both documents, the researcher conducted a simple frequency count with equivalent percentages to the common features of the two documents analyzed. In addition, the researcher provided actual quotations to illustrate the explicit alignment between documents analyzed. The researcher did the data analysis, she being a Mathematics Education specialist herself for her master's degree and Educational Research and Evaluation specialist in her doctorate. She also used the reviews of peers in the finalization of her work. For example, the first reviewer gave corrections on the classification of the mathematics courses in terms of context while the second reviewer gave corrections on the alignment of content. The third reviewer gave corrections on the choice of words in the analysis. The researcher then finalized her analysis on the documents based on the peer qualitative reviews.

## Findings / Results

*Alignment of the BSEd Major in Mathematics Program with the Core Competencies of PISA Mathematics Literacy Framework*

Table 1 shows the results of the alignment of the core competencies (i.e., reasoning and problem-solving) in the PISA 2021 Mathematics Framework vis-à-vis the program outcomes, performance indicators, and courses set in the BSEd Major in Mathematics.

*Table 1. Alignment of the PISA 2021 Mathematics Reasoning Processes with the BSEd Major in Mathematics Program Outcomes and Indicators*

Code	Reasoning Processes in PISA 2021 Mathematics Literacy Framework	Program Outcomes and Performance Indicators in the BSEd Major in Mathematics Program			
		General Program Outcomes (PQF)	Program Outcomes in Teacher Education	Program Outcomes for Mathematics Major	Performance Indicators
R1	Draw a simple conclusion	CMOPOG12	CMOPOTE22	CMOPOTEM3 31	CMOPOTEPI3 3332
R2	Select an appropriate justification	CMOPOG12	CMOPOTE22	CMOPOTEM3 31	CMOPOTEPI3 3332
R3	Explain why a mathematical result or conclusion does or does not make sense given the context of a problem	CMOPOG12	CMOPOTE22	CMOPOTEM3 31	CMOPOTEPI3 3311
R4	Represent a problem in a different way, including organizing it according to mathematical concepts and making appropriate assumptions	CMOPOG11	CMOPOTE22	CMOPOTEM3 35	CMOPOTEPI3 3351
R5	Utilize definitions, rules, and formal systems as well as employing algorithms and computational thinking	CMOPOG11	CMOPOTE22	CMOPOTEM3 31	CMOPOTEPI3 3312
R6	Explain and defend a justification for the identified or devised representation of a real-world situation	CMOPOG12	CMOPOTE22	CMOPOTEM3 33	CMOPOTEPI3 3331
R7	Explain or defend a justification for the processes and procedures or simulations used to determine a mathematical result or solution	CMOPOG12	CMOPOTE22	CMOPOTEM33 1	CMOPOTEPI3 3312
R8	Identify the limits of the model used to solve a problem	CMOPOG11	CMOPOTE22	CMOPOTEM3 35	CMOPOTEPI3 3351
R9	Understand definitions, rules, and formal systems as well as employing algorithms and computational reasoning	CMOPOG11	CMOPOTE22	CMOPOTEM33 1	CMOPOTEPI3 3312
R10	Justify the identified or devised representation of a real-world situation	CMOPOG12	CMOPOTE22	CMOPOTEM3 33	CMOPOTEPI3 3331
R11	Provide a justification for the processes and procedures used to determine a mathematical result or solution	CMOPOG12	CMOPOTE22	CMOPOTEM33 1	CMOPOTEPI3 3312
R12	Reflect on mathematical arguments, explaining and justifying the mathematical result	CMOPOG12	CMOPOTE22	CMOPOTEM3 33	CMOPOTEPI3 3332
R13	Critique the limits of the model used to solve a problem	CMOPOG12	CMOPOTE22	CMOPOTEM3 35	CMOPOTEPI3 3351
R14	Interpret a mathematical result back into the real-world context to explain the meaning of the results	CMOPOG12	CMOPOTE22	CMOPOTEM3 33	CMOPOTEPI3 3311

Table 1. Continued

Code	Reasoning Processes in PISA 2021 Mathematics Literacy Framework	Program Outcomes and Performance Indicators in the BEd Major in Mathematics Program			
		General Program Outcomes (PQF)	Program Outcomes in Teacher Education	Program Outcomes for Mathematics Major	Performance Indicators
R15	Explain the relationships between the context-specific language of a problem and the symbolic and formal language needed to represent it mathematically.	CMOPOG12	CMOPOTE22	CMOPOTEM3 33	CMOPOTEPI3 3311
R16	Reflect on mathematical solutions and create explanations and arguments that support, refute, or qualify a mathematical solution to a contextualized problem	CMOPOG12	CMOPOTE22	CMOPOTEM3 35	CMOPOTEPI3 3351
R17	Analyze similarities and differences between a computational model and the mathematical problem that it is modeling	CMOPOG12	CMOPOTE22	CMOPOTEM3 33	CMOPOTEPI3 3331
R18	Explain how a simple algorithm works and detect and correct errors in algorithms and programs	CMOPOG12	CMOPOTE22	CMOPOTEM3 1	CMOPOTEPI3 3312

As shown in Table 1, two out of the five *general program outcomes* for the bachelor's degree could already cover the 18 PISA reasoning processes. Reasoning processes require effective communication either in English or Filipino in oral or written form. Thus, the 14 reasoning processes that need explaining, justifying, analyzing, or concluding could be encompassed by the stated program outcome that requires the graduates to "effectively communicate in English and Filipino, both orally and in writing (CMOPOG12)." Similarly, the program outcome stated as "articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11)," could cover four of the reasoning processes, which require giving of definitions, rules, and formal systems or employment of algorithms, models or solutions to problems. The three other general program outcomes in the BEd Mathematics program that were not capturing the reasoning processes required in PISA mathematics literacy are: 1) work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor); 2) act in recognition of professional, social, and ethical responsibility; and 3) preserve and promote "Filipino historical and cultural heritage (based on RA 7722).

In terms of the *teacher education program outcomes*, among the eight program outcomes, the one saying that the graduates are expected to "demonstrate mastery of the subject matter/discipline (CMOPOTE22)" is the most relevant and so broadly stated to cover all the 18 reasoning processes in PISA mathematics literacy framework. However, the seven other *program outcomes* are not necessarily focused on the reasoning processes in PISA mathematics literacy and these are: 1) articulate the rootedness of education in philosophical, socio-cultural, historical, psychological, and political contexts; 2) facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment; 3) develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners; 4) apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices; 5) demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes; 6) practice professional and ethical teaching standards sensitive to local, national, and global realities; and 7) pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CHED, 2017).

In terms of the *mathematics-specific program outcomes*, three of the seven outcomes could cover the 18 reasoning processes. These include the following: 1) manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics (CMOPOTEM333), which covers six of the reasoning processes; 2) exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers eight of the reasoning processes; and 3) demonstrate proficiency in problem-solving by solving and creating routine and non-routine problems with different levels of complexity (CMOPOTEM335), which covers four of the reasoning processes. The four other mathematics-specific program outcomes, which were viewed not necessarily covering the PISA reasoning processes but aligned with PPST, are: 1) exhibit proficiency in relating mathematics to other curricular areas; 2) demonstrate competence in designing, constructing, and utilizing different forms of assessment in mathematics; 3) use effectively appropriate approaches, methods, and techniques in teaching mathematics including technological tools; and 4) appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery, and gaining insights of the world (CHED, 2017).

In terms of the *performance indicators* of mathematics-specific program outcomes, only five of the 25 indicators could capture the 18 PISA reasoning processes, and these are: 1) explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed; (2) demonstrate in detail basic mathematical procedures; 3) demonstrate skills in various methods of learning in mathematics such as conducting investigations, modeling, and doing research; 4) create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem-solving, and critical thinking; and 5) demonstrate skills in various problem-solving heuristics.

Table 2 shows the *PISA formulating processes* expected of a mathematically literate 15-year-old learner covered in the BSEd Major in Mathematics program outcomes and performance indicators. It can be gleaned from the table that the earlier cited *general program outcome* covering the reasoning processes could likewise cover the 12 PISA formulating processes. This broadly stated outcome is “articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11).”

Table 2: Alignment of the PISA 2021 Mathematics Formulating Processes with the BSEd Major in Mathematics Program Outcomes and Indicators

Code	Formulating Processes in PISA 2021 Mathematics Literacy Framework	Program Outcomes and Performance Indicators in the BSEd Major in Mathematics Program			
		General Program Outcomes (PQF)	Program Outcomes in Teacher Education	Program Outcomes for Mathematics Major	Performance Indicators
F1	Select a mathematical description or a representation that describes a problem	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 35	CMOPOTEPI M3311
F2	Identify the key variables in a model	CMOPOG1 1	CMOPOTE 22	MOPOTEM33 1	CMOPOTEPI M3331
F3	Select a representation appropriate to the problem context	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 35	CMOPOTEPI M3351
F4	Read, decode and make sense of statements, questions, tasks, objects, or images to create a model of the situation	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 33	CMOPOTEPI M3331
F5	Recognize mathematical structure (including regularities, relationships, and patterns) in problems or situations	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 35	CMOPOTEPI M3351
F6	Identify and describe the mathematical aspects of a real-world problem situation, including identifying the significant variables	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 35	CMOPOTEPI M3351
F7	Simplify or decompose a situation or problem to make it amenable to mathematical analysis	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 35	CMOPOTEPI M3351
F8	Recognize aspects of a problem that correspond with known problems or mathematical concepts, facts, or procedures	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 35	CMOPOTEPI M3351
F9	Translate a problem into a standard mathematical representation or algorithm	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 35	CMOPOTEPI M3351
F10	Use mathematical tools (using appropriate variables, symbols, diagrams) to describe the mathematical structures and/or relationships in a problem	CMOPOG1 1	CMOPOTE 25	CMOPOTEM3 35	CMOPOTEPI M3324
F11	Apply mathematical tools and computing tools to portray mathematical relationships	CMOPOG1 1	CMOPOTE 25	MOPOTEM33 1	CMOPOTEPI M3324
F12	Identify the constraints, assumptions simplifications in a mathematical model	CMOPOG1 1	CMOPOTE 22	CMOPOTEM3 33	CMOPOTEPI M3331

Regarding the *teacher education program outcomes*, the statement that the graduates are expected to “demonstrate mastery of the subject matter/discipline (CMOPOTE22)” could also cover all the ten formulating processes. The other teacher education program outcome covering two formulating processes is “apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable (CMOPOTE25).”



In terms of the *mathematics-specific program outcomes*, three outcomes could cover the 12 formulating processes in PISA. The outcomes include the following: 1) exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers four of the formulating processes; and 2) manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics (CMOPOTEM333); and 3) demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity (CMOPOTEM335), which covers eight of the formulating processes.

Lastly, in terms of *performance indicators in mathematics*, three indicators could capture the 12 formulating processes in PISA: 1) demonstrate in detail basic mathematical procedures (CMOPOTEPI3312), which covers three processes; 2) utilize appropriate technologies to achieve the learning outcomes (CMOPOTEPI3324), which covers two processes; and 3) demonstrate skills in various problem-solving heuristics (CMOPOTEPI3351), which covers seven processes.

Table 3 shows the 14 *PISA employing processes* expected of a mathematically literate 15-year-old learner and how they are covered in the BSEd Major in Mathematics program outcomes and performance indicators. In addition, Table 3 shows one *general program outcome* that could already cover the 14 PISA employing processes, and this is stated as “articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11).”

Regarding the *teacher education program outcomes*, the statement that the graduates are expected to “demonstrate mastery of the subject matter/discipline (CMOPOTE22)” could already cover 10 PISA employing processes. The other teacher education program outcome covering four employing processes is “apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25).”

Table 3: Alignment of the PISA 2021 Mathematics *Employing Processes* with the BSEd Major in Mathematics Program Outcomes and Indicators

Code	Employing Processes in PISA 2021 Mathematics Literacy Framework	Program Outcomes and Performance Indicators in the BSEd Major in Mathematics Program			
		General Program Outcomes (PQF)	Program Outcomes in Teacher Education	Program Outcomes for Mathematics Major	Performance Indicators
E1	Perform a simple calculation	CMOPOG1 1	CMOPOTE2 2	MOPOTEM33 1	CMOPOTEPI M3312
E2	Select an appropriate strategy from a list	CMOPOG1 1	CMOPOTE2 2	CMOPOTEM3 33	CMOPOTEPI M3351
E3	Implement a given strategy to determine a mathematical solution	CMOPOG1 1	CMOPOTE2 2	CMOPOTEM3 33	CMOPOTEPI M3351
E4	Make mathematical diagrams, graphs, constructions, or computing artifacts	CMOPOG1 1	CMOPOTE2 5	CMOPOTEM3 33	CMOPOTEPI M3351
E5	Understand and utilize constructs based on definitions, rules, and formal systems, including employing familiar algorithms	CMOPOG1 1	CMOPOTE2 2	MOPOTEM33 1	CMOPOTEPI M3312
E6	Develop mathematical diagrams, graphs, constructions, or computing artifacts and extracting mathematical information from them	CMOPOG1 1	CMOPOTE2 5	CMOPOTEM3 33	CMOPOTEPI M3351
E7	Manipulate numbers, graphical and statistical data and information, algebraic expressions and equations, and geometric representations	CMOPOG1 1	CMOPOTE2 5	MOPOTEM33 1	CMOPOTEPI M3312
E8	Articulate a solution, showing and/or summarizing and presenting intermediate mathematical results	CMOPOG1 1	CMOPOTE2 2	MOPOTEM33 1	CMOPOTEPI M3312
E9	Use mathematical tools, including technology, simulations, and computational thinking, to help find exact or approximate solutions	CMOPOG1 1	CMOPOTE2 5	MOPOTEM33 1	CMOPOTEPI M3324
E10	Make sense of, relate, and use a variety of representations when interacting with a problem	CMOPOG1 1	CMOPOTE2 2	CMOPOTEM3 33	CMOPOTEPI M3351
E11	Switch between different representations in the process of finding solutions	CMOPOG1 1	CMOPOTE2 2	CMOPOTEM3 33	CMOPOTEPI M3312

Table 3. Continued

Code	Employing Processes in PISA 2021 Mathematics Literacy Framework	Program Outcomes and Performance Indicators in the BSEd Major in Mathematics Program			
		General Program Outcomes (PQF)	Program Outcomes in Teacher Education	Program Outcomes for Mathematics Major	Performance Indicators
E12	Use a multi-step procedure leading to a mathematical solution, conclusion, or generalization	CMOPOG1 1	CMOPOTE2 2	CMOPOTEM3 33	CMOPOTEPI M3312
E13	Use an understanding of the context to guide or expedite the mathematical solving process, e.g., working to a context-appropriate level of accuracy	CMOPOG1 1	CMOPOTE2 2	CMOPOTEM3 35	CMOPOTEPI M3351
E14	Make generalizations based on the results of applying mathematical procedures to find solutions	CMOPOG1 1	CMOPOTE2 2	MOPOTEM33 1	CMOPOTEPI M3311

In terms of *mathematics-specific program outcomes*, three outcomes could cover the 14 PISA employing processes: 1) exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers six employing processes; 2) manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics (CMOPOTEM333), which covers seven employing processes; and 3) demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity (CMOPOTEM335), which covers one employing process.

Lastly, in terms of *performance indicators in mathematics*, three indicators could capture the 14 PISA employing processes: 1) demonstrate in detail basic mathematical procedures (CMOPOTEPI3312), which covers seven processes; 2) utilize appropriate technologies to achieve the learning outcomes (CMOPOTEPI3324), which covers one process; and 3) demonstrate skills in various problem-solving heuristics (CMOPOTEPI3351), which covers six processes.

Table 4 shows the nine *PISA interpreting processes* expected of a mathematically literate 15-year-old learner covered in the BSEd Major in Mathematics program outcomes and performance indicators. Table 4 shows that one *general program outcome* could already cover the nine PISA interpreting processes, and this is stated as “articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11).” Such a statement is broadly stated that could subsume all interpreting processes.

Regarding the *teacher education program outcomes*, the statement that the graduates are expected to “demonstrate mastery of the subject matter/discipline (CMOPOTE22)” could already cover six interpreting processes. The other teacher education program outcome covering three interpreting processes is “apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25).”

Table 4. Alignment of the PISA 2021 Mathematics Interpreting Processes with the BSEd Major in Mathematics Program Outcomes and Indicators

Code	Interpreting, Applying, and Evaluating Processes in PISA 2021 Mathematics Literacy Framework	Program Outcomes and Performance Indicators in the BSEd Major in Mathematics Program			
		General Program Outcomes (PQF)	Program Outcomes in Teacher Education	Program Outcomes for Mathematics Major	Performance Indicators
I1	Interpret a mathematical result back into the real-world context	CMOPOG1 1	CMOPOTE 22	CMOPOTEM33 3	CMOPOTEPI M3312
I2	Identify whether a mathematical result or conclusion does or does not make sense given the context of a problem	CMOPOG1 1	CMOPOTE 22	CMOPOTEM33 5	CMOPOTEPI M3332
I3	Identify the limits of the model used to solve a problem	CMOPOG1 1	CMOPOTE 25	CMOPOTEM33 5	CMOPOTEPI M3351



Table 4. Continued

Code	Interpreting, Applying, and Evaluating Processes in PISA 2021 Mathematics Literacy Framework	Program Outcomes and Performance Indicators in the BSEd Major in Mathematics Program			
		General Program Outcomes (PQF)	Program Outcomes in Teacher Education	Program Outcomes for Mathematics Major	Performance Indicators
14	Use mathematical tools or computer simulations to ascertain the reasonableness of a mathematical solution and any limits and constraints on that solution, given the context of the problem	CMOPOG1 1	CMOPOTE 25	CMOPOTEM33 5	CMOPOTEPI M3324
15	Interpret mathematical outcomes in a variety of formats in relation to a situation or use; compare or evaluate two or more representations in relation to a situation	CMOPOG1 1	CMOPOTE 22	CMOPOTEM33 3	MOPOTEPI 3311
16	Use knowledge of how the real world impacts the outcomes and calculations of a mathematical procedure or model to make contextual judgments about how the results should be adjusted or applied	CMOPOG1 1	CMOPOTE 25	MOPOTEM331	CMOPOTEPI M3312
17	Construct and communicate explanations and arguments in the context of the problem	CMOPOG1 1	CMOPOTE 22	CMOPOTEM33 5	CMOPOTEPI M3351
18	Recognize [demonstrate, interpret, explain] the extent and limits of mathematical concepts and mathematical solutions	CMOPOG1 1	CMOPOTE 22	MOPOTEM331	CMOPOTEPI M3311
19	Understand the relationship between the context of the problem and the representation of the mathematical solution. Use this understanding to help interpret the solution in context and gauge the feasibility and possible limitations of the solution	CMOPOG1 1	CMOPOTE 22	CMOPOTEM33 5	CMOPOTEPI M3351

In terms of the *mathematics-specific program outcomes*, three outcomes could cover the nine interpreting processes: 1) exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers two of the interpreting processes; and 2) manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics (CMOPOTEM333), which covers two of the interpreting processes; and 3) demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity (CMOPOTEM335), which covers five of the interpreting processes.

Lastly, in terms of *performance indicators in mathematics*, five indicators could capture the nine interpreting processes in PISA. These include the following: 1) explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed (CMOPOTEPI3311), which covers two interpreting processes; 2) demonstrate in detail basic mathematical procedures (CMOPOTEPI3312), which covers two interpreting processes; 3) utilize appropriate technologies to achieve the learning outcomes (CMOPOTEPI3324), which covers one process; 4) create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving, and critical thinking (CMOPOTEPI3332), which covers one interpreting process; and 5) demonstrate skills in various problem solving heuristics (CMOPOTEPI3351), which covers three interpreting processes.

#### *Alignment of BSEd Major in Mathematics Program with the Content Domains in PISA Mathematics Literacy Framework*

PISA 2021 mathematics literacy covers 18 content topics classified into four categories: change and relationships; space and shape; quantity; and uncertainty and data. PISA 2021 introduced four new of the 18 topics, namely: growth phenomena (change and relationships); geometric approximation (space and shape); computer simulations (quantity); and conditional decision making (uncertainty and data) (OECD, 2018). *Growth phenomena* require people to think of data

in a linear relationship and non-linear or exponential relationships like studying the spread of the disease in a flu pandemic and bacterial outbreaks. *The topic of geometric approximations* requires an understanding of traditional space and shape phenomena in a range of typical situations and irregularities. *Computer simulation* is needed in complex problems in mathematics and statistics that are not quickly addressed, like budgeting, saving, experimental probability, and population distribution, where computer simulations are used as a tool for decision making. *Finally, conditional decision-making* is needed in statistics to measure and interpret the variation characteristics of two or more variables to make predictions. The other 14 content topics are functions; algebraic expressions; equations and inequalities; coordinate systems; relationships within and among geometric objects in two or three dimensions; measurement; number and units; arithmetic operations; percent, ratios, and proportions; counting principles; estimation; data collection, representation, and interpretation; data variability and its description; samples and sampling; chance and probability (OECD, 2018). These content categories, which are the same as those set since PISA 2012, were based on the content strands in mathematics in the national curriculum of participating countries.

Table 5 shows the specific content under each category. These content domains in PISA were matched with the range of courses in BSEd Mathematics. The researcher used the grouping of the content of PISA 2021 mathematics in the study of Golla and Reyes (2020) as a reference in matching the PISA content with the 21 BSEd content courses. Of these 21 courses, the 3-unit course on *Mathematics in the Modern World* falls under General Education (CHED, 2013), and the rest are specialization courses with 63 units (CHED, 2017). These courses are History of Mathematics; College and Advanced Algebra; Trigonometry; Plane and Solid Geometry; Logic and Set Theory; Elementary Statistics and Probability; Calculus 1 with Analytic Geometry; Calculus 2; Calculus 3; Modern Geometry; Mathematics of Investment; Number Theory; Linear Algebra; Advanced Statistics; Problem Solving, Mathematical Investigation & Modeling; Principles and Strategies in Teaching Mathematics; Abstract Algebra; Research in Mathematics; Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics); and Assessment and Evaluation in Mathematics (CHED, 2017). The researcher examined the course description of each content course in CMO 75 s, 2017, to determine the mathematics content that maps with each PISA mathematics literacy content.

In PISA 2021, *Space and Shapes* includes patterns, properties of objects, positions and orientations, representations of objects, decoding and encoding of visual information, navigation, and dynamic interaction with real shapes and their representations, movements, and actions in space (OECD, 2018). It also requires functions, concepts, measurement, and geometry software and an emphasis on geometric approximations. In the BSEd Math Curriculum, this content of *Space and Shape* could be learned by the would-be mathematics teachers mainly in the courses in Geometry and Trigonometry, but it also finds application of some concepts in courses like Algebra; Mathematics in the Modern World; Problem Solving, Mathematical Investigation & Modeling; and Technology for Teaching and Learning among others (See Table 5). The program outcomes in teacher education stating that graduates should be able to “demonstrate mastery of the subject matter/discipline” and “apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices,” including that which requires would-be teachers to “exhibit competence in mathematical concepts and procedures” are expected to address this needed content of PISA.

Table 5. Alignment of PISA Mathematics Literacy Content Domains with the Courses in BSEd Major in Mathematics Program

PISA 2021 Mathematics Content Domains	PISA Topics Covered (Golla & Reyes, 2020)	BSEd Content Courses in Mathematics (CMO 75 s.2017)
Space and Shape	Geometric Approximations; Spatial Visualization; Measurement; and Algebra	GEM: Mathematics in the Modern World M101: College and Advanced Algebra M102: Trigonometry M103: Plane and Solid Geometry M106: Calculus 1 with Analytic Geometry M112: Linear Algebra M114: Problem Solving, Mathematical Investigation & Modeling M118: Technology for Teaching and Learning

Table 5. Continued

PISA 2021 Mathematics Content Domains	PISA Topics Covered (Golla & Reyes, 2020)	BSEd Content Courses in Mathematics (CMO 75 s.2017)
Change and Relationship	Algebraic Expressions and Functions; Equations and Inequalities; Algebra in Growth Phenomena; Relationship between & Among Geometrical Objects	M101: College and Advanced Algebra; M102: Trigonometry M103: Plane and Solid Geometry M105: Statistics and Probability; M106: Calculus 1 with Analytic Geometry; M107: Calculus 2 M108: Calculus 3 M109: Modern Geometry M110: Mathematics of Investment M111: Number Theory M112: Linear Algebra M113: Advanced Statistics M114: Problem Solving, Mathematical Investigation & Modeling
Uncertainty and Data	Counting Principles; Probability in Predicting Events; Sampling; Data Collection; and Measures of Central Tendency and Variability	M105: Statistics and Probability M110: Mathematics of Investment M113: Advanced Statistics M114: Problem Solving, Mathematical Investigation & Modeling
Quantity	Making Sense of Data; Statistics in Decision Making; Measurement; Estimation; Number and Number Sense; Numerical Trends and Patterns; Computer Simulation on Complex Problems	GEM: Mathematics in the Modern World M101: College and Advanced Algebra; M102: Trigonometry M103: Plane and Solid Geometry M105: Statistics and Probability; M106: Calculus 1 with Analytic Geometry M108: Calculus 3 M110: Mathematics of Investment M111: Number Theory M112: Linear Algebra M113: Advanced Statistics M114: Problem Solving, Mathematical Investigation & Modeling; M118: Technology for Teaching and Learning

In PISA 2021, *Change and Relationships* involves functions and algebra, algebraic expressions, equations and inequalities, tabular and graphical representations, data representations using statistics, geometric measurement, and growth phenomena (OECD, 2018). In the BSEd Math Curriculum, would-be teachers could learn the content of PISA 2021 mathematics in specialization courses like Algebra, Geometry, and Statistics. There is no single course where change and relationship could be understood, but its content could be learned in 13 mathematics courses, as shown in Table 5. The program outcomes in teacher education aiming for the graduates to “demonstrate mastery of the subject matter/discipline” and “apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices” including that which requires them to “exhibit competence in mathematical concepts and procedures” should remind the designers of courses to provide the needed content of PISA.

In PISA 2021, *Quantity* includes the quantification or measurement of the attributes of objects or entities in the world, their representations, and interpretations. It also involves understanding of numerical trends and patterns, mental computations and estimation, assessment of uncertainties including computer simulations (OECD, 2018). In the BSEd Math Curriculum, this content could be learned by the teachers in the General Education course in Mathematics called the Modern World and in specialization courses like Mathematics Investment, Statistics, and Technology for Teaching and Learning. Like the content domain on *Change and Relationship*, *Quantity* could be learned in 13 mathematics courses (See Table 5). These courses should have been designed considering the teacher education program outcomes specifically in mathematics education emphasizing the need for mastery of the subject matter/discipline and the application of the skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices.

In PISA 2021, the *Uncertainty and Data* category includes recognizing the place of variation in the real world, forming, interpreting, and evaluating conclusions drawn in situations where uncertainty is present (OECD, 2018). At the heart of

this category is the theory of probability and statistics. In the BSEd program for would-be mathematics teachers, there are specialization courses on probability and statistics and advanced statistics where the PISA 2021 mathematics content for uncertainty and data could be addressed. Since the BSEd program targets mastery of the subject matter/discipline and application of the skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices, this PISA requirement should be addressed.

One can infer from Table 5 that each content domain in PISA covers at least four mathematics courses in the BSE Major in Mathematics program. However, looking just at the course titles may not be enough to know how the curriculum for pre-service teachers prepares them for the expectations of the world of work based on the PISA Mathematics framework. As shown in Table 5, the content domains in PISA mathematics are interdisciplinary such that the students should be able to apply knowledge of mathematics from different courses in any problem solving and reasoning activity that they deal with outside mathematics. It is, therefore, necessary that the design of mathematics courses for would-be teachers in the secondary high school program be interdisciplinary, multi-contextual, and multidimensional. Learning mathematics content should happen when applied in different contexts that require their use in solving real-life problems.

*Alignment of BSEd Major in Mathematics Program with the Context Domains in PISA Mathematics Literacy Framework*

The PISA Mathematics Literacy Framework underscores the importance of application of mathematics content and cognitive processes in various contexts from *personal* (e.g., individual activities, family and peers); *occupational* (i.e., job-related concerns like payroll, quality control, etc.); *societal* (i.e., problems that may involve local, national or global matters like public transport, government, policies, etc.); and *scientific* (i.e., issues related to science and technology like weather, ecology, medicine, etc.) (OECD, 2018). To understand if the BSE major in Mathematics captures the different contexts in PISA, the course descriptions of the 21 mathematics courses were examined (see Table 6).

*Table 6: Alignment of the BSE Major in Mathematics Courses with the Context Requirements of PISA 2021 Mathematics Literacy Framework*

BSE Major in Mathematics Courses		PISA 2021 Mathematics Contexts Domain			
Course Code	Title	Personal	Occupational	Societal	Scientific
1. GEM	Mathematics in the Modern World	✓		✓	✓
2. M100	History of Math	✓			
3. M101	College and Advanced Algebra				
4. M102	Trigonometry				
5. M103	Plane and Solid Geometry				
6. M104	Logic and Set Theory				
7. M105	Elementary Statistics and Probability		✓		✓
8. M106	Calculus 1 with Analytic Geometry				
9. M107	Calculus 2				
10. M108	Calculus 3				
11. M109	Modern Geometry				
12. M110	Mathematics of Investment		✓	✓	
13. M111	Number Theory				
14. M112	Linear Algebra				
15. M113	Advanced Statistics				✓
16. M114	Problem Solving, Mathematical Investigation & Modeling				✓
17. M115	Principles and Strategies in Teaching Mathematics		✓		
18. M116	Abstract Algebra				
19. M117	Research in Mathematics		✓		✓
20. M118	Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics)		✓		✓
21. M119	Assessment and Evaluation in Mathematics		✓		
<b>Total</b>	<b>21</b>	<b>2</b>	<b>6</b>	<b>2</b>	<b>6</b>

Table 6 shows that 10 out of 21 courses or about 48%, explicitly reflect the contexts of PISA mathematics literacy. The course Mathematics in the Modern World is the only course that explicitly targets the application of mathematics in three of the four contexts: personal, societal, and scientific. The integration of learning mathematics at the *occupational* level is

the most common context that is targeted mainly through courses involving the teaching of mathematics in one's profession as a teacher (e.g., Elementary Statistics and Probability, Mathematics of Investment, Principles and Strategies in Teaching Mathematics, Assessment and Evaluation in Mathematics). The second most common context is *scientific*, where there is an explicit mentioning of nature and environment (e.g., Mathematics in the Modern World); use of technology in mathematics or computer software like SPSS (e.g., Elementary Statistics and Probability, Advanced Statistics, Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics)); and phrases indicating scientific investigations (e.g., Problem Solving, Mathematical Investigation & Modeling). Courses that mention the application of mathematics in real-life contexts were also classified as scientific (e.g., Research in Mathematics). Finally, courses classified to have considered *personal contexts* mentioned terms like the humanistic aspect of mathematics (e.g., History of Math) and personal finances (e.g., Mathematics in the Modern World). Meanwhile, courses classified to have considered *social contexts* are those that have mentioned the word "social" (e.g., Mathematics in the Modern World) and economics/business (e.g., Mathematics and Investment). Overall, Table 6 reveals that among the four contexts in PISA, the *personal* and *societal* applications of mathematics in the BSEd curriculum are less emphasized.

The *program outcomes* were also analyzed to find out if they explicitly reflect the need for learning to be applied in various contexts. The *general program outcomes* for the bachelor's degree program explicitly reflect the value of applying learning at the personal, occupational, societal, and scientific contexts. The *teacher education program outcomes* are stated in the same way. However, when it comes to the statements of *program outcomes and performance indicators in mathematics*, the explicit linking of mathematics to various contexts is true only to those statements meant for courses focused on pedagogical content knowledge. The most popular contexts targeted are *occupational*, followed by *scientific* contexts. A few statements reflect personal and societal contexts. Such results are consistent with the analysis made on the integration of contexts at the level of the courses with reference to the course descriptions.

The results show a gap in how mathematics is taught among would-be teachers. Furthermore, the lack of direct application of mathematical concepts and procedures in various contexts may lead to a poor appreciation of the students' value of high-level mathematics in their personal, occupational, societal, and scientific contexts, which are so much valued in PISA.

In PISA, every assessment of reasoning and problem-solving process that necessitates content knowledge is applied in any of the four contexts. Hence, if the students are not used to solving mathematical problems in various contexts, they would not perform well given problem-solving items. This unfamiliarity with the application of problem-solving skills in multiple contexts could explain students' poor proficiency in PISA mathematics. Focusing on problem solving in various contexts in the courses for would-be teachers may also influence how they will teach mathematics among their students. Thus, the mathematics curriculum content and pedagogy must be improved by providing ample practice in problem solving in various context. As the course descriptions and syllabus design could inform course content and delivery, there is a need to highlight in the course descriptions and even in the curriculum framework the importance of contextualized teaching of mathematics in the teacher education program so that students will be able to appreciate the value of learning it particularly in their personal and professional life. Highlighting applications of mathematics in addressing societal and scientific problems is extremely important. Again, there is the need to model to would-be teachers how to explicitly teach problem solving in various contexts as reflected in course descriptions and syllabi. In recent years, many mathematics teachers have failed to teach mathematics and its application in different contexts. This failure could explain the poor mathematics proficiency of the 15-year old learners assessed in PISA 2018, where more than 80% of the students assessed were below proficiency level (DepEd, 2019b).

#### *Alignment of BSEd Major in Mathematics Program with the 21st Century Skills in PISA Mathematics Literacy Framework*

The PISA 2021 Mathematics Literacy Framework also includes eight 21st century skills believed necessary for 15-year-old learners to possess. These 21st century skills are: critical thinking; creativity; research and inquiry; self-direction, initiative, and persistence; information use; systems thinking; communication; and reflection (OECD, 2018). Using the Partnership for the 21st Century Framework and Definitions (Battelle for Kids, 2019), *critical thinking* is the ability to use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation. *Creativity* refers to one's ability to think creatively by creating new and worthwhile ideas, working creatively with others, or being open to new and diverse ideas. *Research and Inquiry* refers to gathering and evaluating information to satisfy one's curiosity, while *Self-direction, initiative, and persistence* refer to how one manages goals and time in doing tasks without direct oversight and one's demonstration of initiative and perseverance to advancing one's skills towards a professional level.

Moreover, *Information Use* refers to the accurate, creative, and ethical use of information to address the issues or problem at hand, while *Systems thinking* refers to one's ability to analyze how parts of a whole interact with each other to produce overall outcomes in a complex system. *Communication* refers to one's ability to express thoughts using oral, written, and non-verbal communication skills in various forms, purposes, and contexts. Finally, *Reflection* refers to one's critical examination of past and present experiences and processes to inform future progress.

Table 7 shows the eight 21st century skills targeted in the PISA 2021 Mathematics Literacy Framework and how they are addressed in the design of the BSEd Major in Mathematics. At least three program outcomes or performance indicators



statements could address each of the 21st century skills targeted by PISA 2021 Mathematics. Therefore, it is expected that would-be mathematics teachers would eventually develop the same 21st century skills among their learners.

*Table 7. Alignment of the BSE Major in Mathematics Courses with the 21st Century Skills in PISA 2021 Mathematics Literacy Framework*

21st Century Skills in PISA 2021 Mathematics Literacy Framework	Philippine BSEd Major in Mathematics in CMO 75 s. 2017					Total
	General Program Outcomes (n = 5)	Teacher Education Program Outcomes (n= 8)	BSEd Mathematics Program Outcomes (n=7)	BSEd Mathematics Performance Indicators (n= 25)	Course Descriptions of Specialization Courses and General Education Mathematics (n=21 courses)	
Critical Thinking			1	3	6	10
Creativity		1	1	4	1	7
Research and Inquiry		1	1	1	3	6
Self-direction, initiative, and Persistence	1	1	1	1		4
Information Use	1	2	1	4	13	21
Systems Thinking	1	3		5	3	12
Communication	2		1	4	4	11
Reflection			1	2		3

Table 7 shows that not all the general and specific program outcomes and course descriptions capture the eight 21st century skills. Representation of all these 21st century skills is evident in the performance indicators. Table 8 shows samples of these program outcomes and performance indicators representing each of the 21st century skills.

*Table 8. Alignment of the BSE Major in Mathematics Courses with the 21st Century Skills in PISA 2021 Mathematics Literacy Framework*

21st Century Skills in PISA 21 Mathematics Framework	Example of a Program Outcome*/Performance Indicator** in BSEd Major in Mathematics Program Addressing the 21st Century Skills
Critical Thinking	Analyze assessment results and use these to improve learning and teaching**
Creativity	Develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners*
Research and Inquiry	Demonstrate skills in various methods of learning in mathematics such as conducting investigations, modeling, and doing research **
Self-direction, Initiative, and Persistence	Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities*
Information Use	Apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices*
Systems Thinking	Exhibit proficiency in relating mathematics to other curricular areas*
Communication	Effectively communicate in English and Filipino, both orally and in writing*
Reflection	Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery, and gaining insights into the world.*

### Discussion

The results of this study revealed alignment to a certain extent of the 53 core competencies, four content domains, four contexts, and eight 21st century skills of the 2021 PISA mathematics literacy with the program outcomes, performance indicators, and course descriptions in the mathematics teacher education curriculum. This result provides hope that the Filipino teachers are trained to meet the quality standards set by PISA. Such review in the alignment of teacher preparation to the challenges of PISA is necessary as teacher quality is the single most important factor for student learning (Coleman et al., 1966; Rivkin, Hanushik, & Kain, 2005, as cited in OECD, 2019b). This means that the first batch of would-be mathematics teachers that the TEIs train for secondary schools was exposed to a mathematics curriculum that equipped them with the required knowledge and competencies that they are expected to develop as well with the JHS students, including the 15-year-old learners in basic education, when they graduate by academic year 2021-2022. However, the BSEd mathematics general and specific program outcomes and performance indicators are broadly stated that they are assumed to cover the intents of PISA 2021 mathematics literacy. Hence, such observed alignment should be verified when would-be mathematics teachers are assessed of their attained learning outcomes.

Moreover, gaps were found in the way the mathematics teacher education curriculum was written as some course descriptions do not explicitly reflect the contexts where mathematics content and competencies are expected to be applied. In PISA, context is an important aspect of mathematics literacy. It is in context where mathematical problems are applied. Context is also viewed important in the assessment framework of mathematics literacy in the SEA-PLM for Grade 5 learners (UNICEF & SEAMEO, 2019), where the Philippines has also participated similar to PISA. Therefore, the mathematics curriculum should reflect the various contexts where mathematical problems are applied (Brown & Redmond, 2017; Fonteles Furtado et al., 2019; Salgado, 2017).

Four varied contexts are considered in PISA mathematics literacy and these are personal, occupational, societal, and scientific (OECD, 2018). These contexts were not explicitly targeted in the Philippine BSEd mathematics curriculum. Although contextualization is encouraged given the teacher education program outcome that states, "The graduates have the ability to practice professional and ethical teaching standards sensitive to the local, national, and global realities" (CHED, 2017, p. 4), applying mathematics in different contexts was not explicit in the descriptions of mathematics courses. In PISA test development, however, when an item is just measuring a mathematical construct without directly applying to an outside context, this item is categorized under scientific context (OECD, 2018). In the SEA-PLM, a regional assessment for Grade 5 learners which covers mathematics literacy as well, items that do not specifically mention a context outside mathematics were categorized as intra-mathematical contexts (UNICEF & SEAMEO, 2019).

Aside from the lack of explicit inclusion of various contexts in the descriptions of mathematics courses, how context is viewed to meet the expectations of the Kto12 curriculum may not be aligned with PISA mathematics literacy. Golla and Reyes (2020), reported that context in PISA mathematics literacy framework is different from how context is viewed in the Philippine Kto12 mathematics curriculum. While PISA mathematics literacy framework emphasizes the need to apply mathematics in real-life contexts from personal to occupational, societal, and scientific (OECD, 2018), the Philippine Kto12 curriculum, on the other hand, defines context to refer to beliefs, environment, language, culture, and learner's prior knowledge (DepEd, 2016). The statements of standards and competencies are not also explicit on the integration of mathematics in various contexts. Balagtas et al. (2020), also revealed that the context of mathematics in the SEA-PLM is almost the same as that for PISA but different from how it is conceived in the Philippine mathematics curriculum.

In addition, this study also revealed that some 21st century skills that are newly introduced in PISA 2021 mathematics literacy framework like reflection, self-direction, initiative, and persistence, were not also explicitly targeted in mathematics courses. Hence, areas for improvement in the mathematics teacher education curriculum should explicitly reflect the contexts and the 21st century skills that PISA mathematics literacy emphasizes.

### Conclusions

The analysis of the alignment of the BSEd Major in Mathematics with PISA 2021 mathematics literacy framework as a benchmark of the effectiveness of the Kto12 reform program informs the needed continuous updating of the teacher education program in the Philippines. The results affirmed that the CHED-mandated BSEd in Mathematics program meets to a certain extent the content demands, cognitive processes, and 21st century skills emphasized in PISA mathematics. However, the program lacks consistent emphasis on applying mathematics in different contexts particularly in personal and societal contexts and on integrating some 21st century skills like reflection, self-direction, initiative, and persistence that PISA 2021 Mathematics Literacy Framework emphasizes. This apparent gap on the contextualization of mathematics and integration of all valued 21st century skills based on the PISA 2021 Mathematics Literacy Framework may suggest that the Philippine mathematics teacher curriculum does not fully meet yet the international standards for quality education. Hence, the current Philippine curriculum in the preparation of teachers for the secondary level may not yet fully produce the desired quality of mathematics teachers. These desired mathematics teachers are equipped with all the needed skills to effectively develop the mathematical knowledge, skills, and competencies expected of the mathematically literate 15-year-old learners to survive in different contexts.

### Recommendations

The results of the analysis on the PSGs for the BSEd Major in Mathematics in terms of its alignment to the PISA 2021 Mathematics Literacy Framework offer the following recommendations. *First*, there is a need for CHED to update the PSGs in CMO 75 s. 2017 to include the framework of PISA and other ILSAs among the drivers in crafting the program outcomes, performance indicators, and course descriptions in the mathematics teacher education curriculum. *Second*, there is a need to review how the program outcomes, performance indicators, and course descriptions are stated to explicitly reflect the core competencies, new content areas (e.g., computer simulations, growth phenomena, conditional decision making), applications of mathematics in less popular contexts (e.g., personal, societal); and soft areas of 21st century skills (e.g., self-direction, initiative, persistence, reflection). *Third*, introduce ILSAs particularly PISA in courses like *Assessment and Evaluation in Mathematics* and *Research in Mathematics* in the bachelor's degree program so that mathematics teachers could have a better understanding of the framework of mathematics literacy as defined and assessed internationally. *Fourth*, TEIs should conduct curriculum quality audit to their mathematics teacher education program to examine if it is aligned with the requirements of PISA 2021 Mathematics Literacy Framework. *Lastly*, further studies be done to analyze the responsiveness of the mathematics teacher education program to the innovative

assessment areas in PISA like creative thinking, collaborative problem solving, and financial literacy that are expected to be addressed as well by an internationally-benchmarked mathematics teacher education program.

### Limitations

The researcher recognizes several limitations of the study. *First*, the analysis of the mathematics teacher education curriculum focused only on the four dimensions (i.e., core competencies, content, context, 21st century skills) of PISA 2021 mathematics literacy. The curriculum could also be analyzed in terms of other features of PISA like the innovative assessment areas such as financial literacy, creative thinking, and collaborative problem-solving skills, which a mathematics curriculum should also cover. *Second*, the researcher also acknowledges that the methodology of content analysis may not be sufficient in bringing out the potential gaps in the curriculum for mathematics teachers. As the analysis of the mathematics teacher education curriculum was based only on the stated program outcomes, performance indicators, and course descriptions defined in the CMO 75 series of 2017, the information may be limited. Furthermore, it is understood that the TEIs may go beyond what is stipulated in the CHED-mandated curriculum. Hence, any found gap in this study may just be true to the CHED-released PSGs but may not be true to the curriculum that the TEIs actually implement in their institution. *Third*, the researcher also recognizes that the review was based on the PISA 2021 Mathematics Literacy Assessment Framework, which does not include the analysis of the actual assessment results. Hence, any claimed alignment of the national curriculum for mathematics teacher preparation with the PISA 2021 Mathematics Literacy Framework may not be true in reality as the implemented curriculum may not be faithful to the intended curriculum, which this analysis failed to cover due to limited time and resources.

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