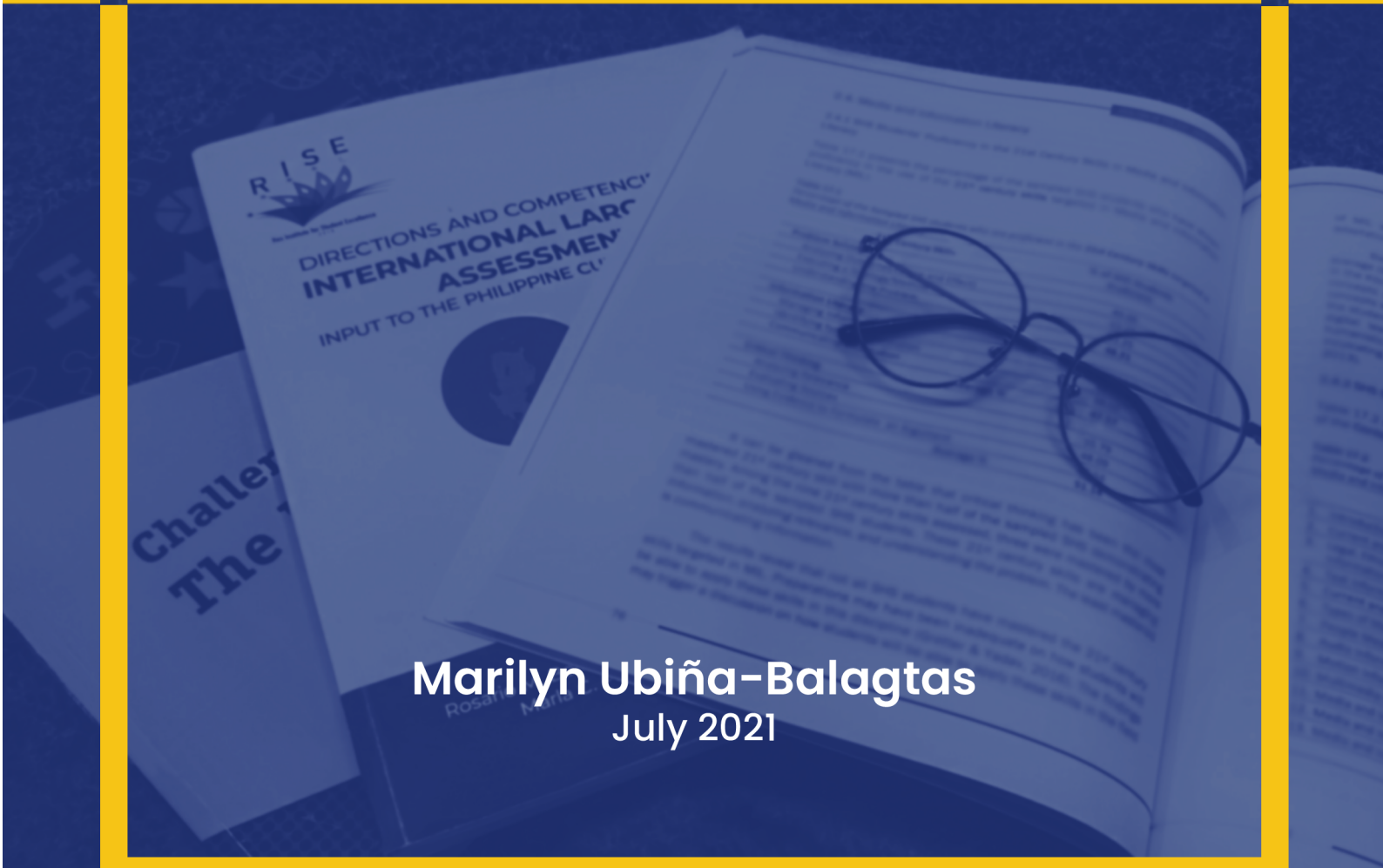
PHILIPPINE NORMAL UNIVERSITY
The National Center for Teacher Education
Taft Avenue, Manila

Responsiveness of the Mathematics Teacher Preparation to the Challenges of PISA



Marilyn Ubiña-Balagtas
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Preface

The teacher education program is the starting point of the formation of teachers. It defines how pre-service teachers should be developed and the competencies they should be equipped with before they become full-fledged teachers.

In the Philippines, the Commission on Higher Education (CHED) is the responsible education agency that sets policies, standards, and guidelines (PSGs) in offering teacher education programs. In 2017, CHED released its PSGs for the bachelor's program in secondary education through its CHED Memorandum Order (CMO) No. 75 series of 2017 to provide the basis for the framework, program outcomes, performance indicators, and courses that should constitute a teacher education program. The CMO stipulates the bases in the formulation of the PSGs to include the Philippines Qualifications Framework, the Kto12 Curriculum, and the Philippine Professional Standards for Teachers (PPST). The CMO does not mention, however, the reference to the standards set in international communities.

As the Philippines has embarked on participation in international large-scale assessments (ILSAs) as a possible source of the indicators of the effectiveness of the Kto12 program, the framework of assessments could reflect the curriculum standards that should be targeted by participating countries. The dismal results of the Philippines' participation in the ILSAs like the Programme for International Student Assessment (PISA) in 2018 prompted the review of the basic education curriculum, improvement of the learning environment, upskilling of teachers, and engagement of different stakeholders in quality reform programs launched by the Department of Education (DepEd). Likewise, the teacher education program also began to examine teacher preparation programs and their responsiveness to the challenges of PISA.

The need for TEIs to analyze their programs alongside the ILSA demands gave rise to the conduct of this study, which examined the preparation of the mathematics teachers in secondary education since this is the subject area frequently assessed among the three ILSAs that the Philippines has participated in at the time of the Kto12 program. The ILSAs that have covered mathematics in their assessment areas include PISA, Trends in International Mathematics and Science Survey (TIMSS), and the Southeast Asia Primary Learning Metrics (SEA-PLM). Since PISA, administered to 15-year old learners, is used for system assessment, the challenges it posed to the participating country's education system triggered the need to study how responsive the current teacher education program for majors in mathematics is in meeting such challenges.

In examining the responsiveness of the mathematics teacher preparation to the challenges of PISA, the CHED mandated program for mathematics teachers in the secondary education was mapped with the PISA mathematics literacy framework and other innovative assessment areas such as financial literacy, creative thinking, and collaborative problem solving. The purpose of such mapping was to determine if the mathematics teachers are prepared to meet both the national and international standards for the K to 12 program. The results of such analysis are expected to inform areas for updating the teacher education program for mathematics teachers in secondary education.

The report was structured to begin with some background information of the teacher preparation in the Philippines, the purpose of the study, the PISA framework of the mathematics literacy, financial literacy, creative thinking, and problem solving as well as that of the teacher education program for mathematics teachers. The methodology of the study was also described and so with its results, the conclusions that were drawn from the results, and the recommendations offered considering the limitations and implications of the study.

This study is envisioned to be of use as a reference to the policy and curriculum crafters and implementers of the teacher preparation program for mathematics teachers in secondary education in the country. May the identified areas for improvement in the Bachelor in Secondary Education (BSEd) major in mathematics in this study in terms of its program outcomes, performance indicators, and course descriptions be found useful in the needed updating of the mathematics teacher preparation program in the country to help meet the quality standards set in the international community.

MUB

List of Acronyms

BSEd	Bachelor of Secondary Education
CHED	Commission on Higher Education
CMO	CHED Memorandum Order
CPS	Collaborative Problem Solving
DepEd	Department of Education
GEM	General Education Mathematics
ICT	Information and Communications Technology
ILSAs	International Large-Scale Assessments
JHS	Junior High School
NCBTS	National Competency-based Teacher Standards
OECD	Organization for the Economic Co-operation and Development
PCK	Pedagogical Content Knowledge
PISA	Programme for International Student Assessment
PNU	Philippine Normal University
PPST	Philippine Professional Standards for Teachers
PQF	Philippines Qualifications Framework
PSGs	Program, Standards and Guidelines
TEIs	Teacher Education Institutions
TIMSS	Trends in International Mathematics and Science Survey
TTL	Technology for Teaching and Learning
RA	Republic Act
SEA-PLM	Southeast Asia Primary Learning Metrics
SHS	Senior High School

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Executive Summary

The Philippine's participation in the Programme for International Student Assessment (PISA) in 2018 has posed questions on the effectiveness of many educational reforms introduced in the country. The dismal performance of15-year old Filipino learners in PISA assessed areas including mathematics, triggered the development of newer programs that help improve access to and quality of basic education in the country.

The Philippines shall continue to participate in PISA and other international large-scale assessments to gather relevant information that could inform educational policies and programs in improving the state of education including teacher education in the country. A study that examines the level of responsiveness of teacher education programs to the challenges of PISA is necessary. Specifically, the mathematics teacher preparation program that prepares pre-service teachers in teaching mathematics in Junior and Senior High Schools needs a closer examination as mathematics is commonly assessed in all International Large-Scale Assessments (ILSAs) that the Philippines has participated in and where Filipino learners consistently reveal poor mathematics proficiency.

This study was conceived to examine if the Bachelor of Secondary Education (BSEd) Major in Mathematics as defined in the CHED Memorandum Order No. 75 s. 2017, which Teacher Education Institutions (TEIs) in the Philippines implement, responds to the demands of PISA as one source of the indicators of the effectiveness of the Kto12 program. It is assumed that the BSE Mathematics program has been designed to respond to the needs of the Kto12 program and to meet global standards such as those set in PISA for 15-year old learners. Hence, this study aimed to test such assumption. In particular, the study sought answers to these two questions:

1) 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 the demands of PISA mathematics literacy, financial literacy, collaborative problem solving, and creative thinking; and
2) What improvements in the BSEd Major in Mathematics program are recommended for it to meet the demands of PISA?

The study is a qualitative-descriptive research which makes use of documents and content analysis to describe the responsiveness of the mathematics teacher preparation program to the demands and challenges of PISA mathematics literacy, financial literacy, collaborative problem solving, and creative thinking. The PISA frameworks made available in the OECD website and the CHED Memorandum Order (CMO) No. 75, series of 2017, which sets the Policies, Standards and Guidelines

(PSGs) for BSEd mathematics were analyzed. The author worked on the analysis of these documents for her sabbatical research, but her analysis was reviewed by three mathematics experts who have been teaching mathematics for at least 14 years and at most 37 years in the teacher education program and who conducted an analysis of the PISA mathematics framework vis-à-vis the Kto12 mathematics curriculum. The study is limited to the analysis of the documents that serve as the main reference of the Teacher Education Institutions (TEIs) in the preparation of mathematics teachers in the Philippines.

The results confirm that the CHED mandated BSEd Major in Mathematics program has been designed to meet the following features:

- The content demands, cognitive processes, 21st century skills, and some contexts emphasized in PISA mathematics literacy.
- The content demands, cognitive processes, and some contexts emphasized in PISA financial literacy.
- Some of the cognitive and social processes in PISA collaborative problem solving skills.
- Some of the content domains and competencies of PISA creative thinking.

However, the CHED mandated BSEd Major in Mathematics program has the following gaps with reference to the PISA frameworks:

- It lacks emphasis on the application of PISA mathematics and financial literacy in different contexts from personal to home, occupational, societal, and global settings based on how courses are described in the CMO 75 series of 2017.
- It fails to explicitly target the development of PISA collaborative problem-solving processes in the way course descriptions are written.
- It fails to explicitly cover the development of written and visual creative expressions and creative social problem solving as well as the competencies in generating diverse ideas and in evaluating and improving ideas, which are all valued in the PISA creative thinking framework.

The gaps found in the PSGs for the BSEd Major in Mathematics program may suggest unpreparedness of would-be secondary mathematics teachers in teaching mathematics to 15-year-old learners in a manner that would meet the expectations of PISA. Hence, the following recommendations for the improvement of the mathematics teacher preparation program are given:

- Update the CMO 75 s. 2017 on the PSGs for BSEd to make it responsive to the demands of PISA and other ILSAs that the Philippines subscribed to participate in to gather indicators of the effectiveness of the quality reform programs in the country's educational system.

- Review and contextualize the mathematics teacher preparation program to ensure that it meets national and global standards particularly the demands of PISA, which is a good reference for educational system improvement.
- Deepen would-be mathematics teachers' content knowledge, cognitive processes, and 21st century skills and how they are applied in personal, occupational, societal, and global contexts similar to how mathematics knowledge and skills are assessed in PISA.
- Strengthen financial literacy education in the mathematics teacher preparation program to ensure that would-be mathematics teachers develop good foundational knowledge and skills in financial literacy for them to effectively teach the same to 15-year-old learners since good financial management is a key component of a successful life in this 21st century.
- Target explicit development of would-be mathematics teachers' collaborative problem-solving skills that PISA finds essential in addressing societal and global problems.
- Target explicit development of would-be mathematics teachers' creative thinking in mathematics as it is an important skill in solving personal, occupational, societal, and global problems.
- Increase awareness and understanding of would-be mathematics teachers and teacher educators on the framework and impact of PISA in addressing the issues and challenges confronting the learning crisis in the Philippines.
- Adapt the recommended improvements in the statements of general program outcomes, teacher education program outcomes, discipline-specific program outcomes, and performance indicators in the BSEd Mathematics program including the suggested refinements in the course descriptions in the CMO 75 s. 2017 to address the identified gaps based on the emphasis of PISA.

INTRODUCTION

The quality of basic education has been the focus of forums and discussions since the release of the dismal results of the PISA 2018 on December 3, 2019. The results showed the Philippines at the bottom among 79 participating countries in reading literacy and 2nd from the bottom in mathematics and scientific literacy. Such alarming results signaled the needed cooperation and support of every education stakeholder in efforts to improve the quality of basic education in the country.

PISA is an international large-scale assessment (ILSA) administered every three years to 15-year-old learners by OECD or Organization for the Economic Co-operation and Development (OECD, 2019). It started in 2000, but the Philippines participated only in its 6th cycle in 2018 after graduating the first batch of senior high school (SHS) students under the Kto12 Program. PISA covers three major assessment areas such as reading, mathematics, and scientific literacies. Then an innovative assessment area is introduced every cycle, which focuses on 21st century skills like creative thinking, collaborative problem solving, financial literacy, and global competence. The Philippines participated in PISA in 2018 to gather indicators of the effectiveness of the Kto12 reform (DepEd, 2019). The Department of Education has set to participate again in PISA in the next cycle to monitor the improvements in the quality of basic education in the country.

Considering the intention of gathering indicators of the effectiveness of the currently implemented Kto12 Program, the dismal results of the Philippines' participation in PISA 2018 and so with the results of other ILSAs like Trends in International Mathematics Science Survey (TIMSS) and the Southeast Asia Primary Learning Metrics (SEA-PLM) that the Philippines has participated in 2019, could indicate the need to review and update the current curriculum in basic education. Studies have been conducted to examine the alignment of the PISA framework vis-à-vis the Kto12 Curriculum (Balagtas et al., 2020) and so with TIMSS and SEA-PLM (Balagtas et al., 2020). The results show gaps in the Kto12 Curriculum not much on the content but more on its cognitive demand, contextualization in different levels, and interconnectedness with different areas.

Among the curriculum areas that are assessed in ILSAs that the Philippines has participated in even before the Kto12 program, mathematics is a common area for assessment. Mathematics literacy is assessed in SEA-PLM for Grade 5 learners, TIMSS for Grade 4 and 8 learners, and in PISA for 15-year old learners. The results of the Philippines' participation in all these ILSAs reveal that the mathematics literacy of the Filipino learners is consistently below the international benchmarks.

Hence, this study was conducted to examine how the mathematics teachers are prepared in teacher education institutions (TEIs) to meet the challenges of ILSAs. As PISA is the closest ILSA to the time when the basic education students transition to higher education, its mathematics literacy framework is a good reference in the review of the teacher education curriculum. It is imperative to know if the teachers, particularly those teaching mathematics in the secondary level that the TEIs produce, could likewise demonstrate the competencies required in PISA. Hence, the study focused on examining the current BSEd mathematics curriculum of TEIs as prescribed by the Commission on Higher Education (CHED). It investigated if the BSEd mathematics curriculum prepares mathematics teachers who could develop the competencies that PISA expects from 15-year old learners.

Specifically, the study analyzed the responsiveness of the CHED-mandated curriculum for Bachelor in Secondary Education (BSEd) major in mathematics in meeting the expected knowledge and skills of teachers who will be teaching the junior high school (JHS) students in mathematics based on the PISA mathematics literacy framework. Likewise, it also examined whether the BSEd mathematics program covers the innovative assessment areas in PISA such as financial literacy, collaborative problem solving, and creative thinking since these areas should be emphasized as well in the mathematics education program. It is hoped that the study could inform TEIs on how to prepare mathematics teachers in the secondary level in meeting not only the standards set in the Philippine Professional Standards for Teachers (PPST), but also the standards set in the international community as captured in PISA.

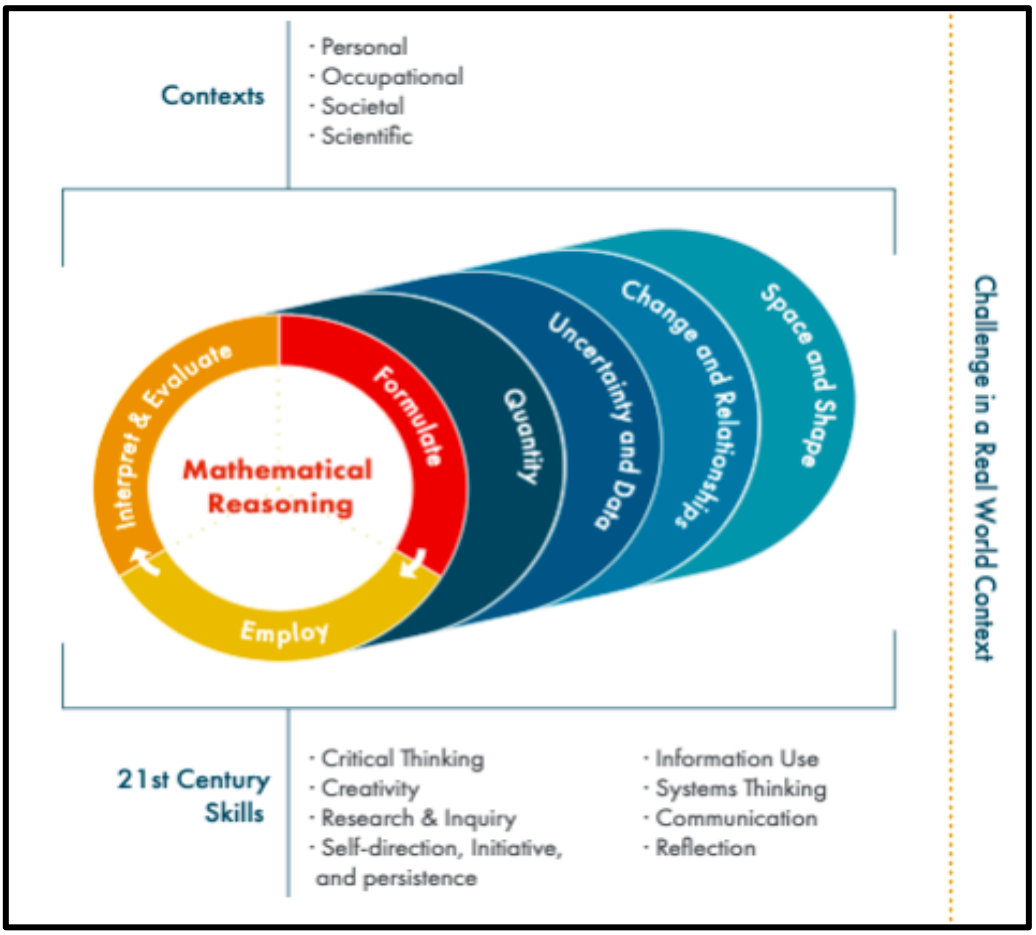
Framework of Mathematics Literacy in PISA 2021

Since the first administration of PISA in 2000 and in all its triennial cycles, different literacies of 15-year-old learners including mathematics literacy have been assessed to inform education systems. The OECD usually releases in its website the framework of the areas assessed in PISA, including that of mathematics literacy, at least two years before its administration. The PISA framework for assessment could be a good reference of participating countries in developing or reviewing their curriculum particularly for the JHS students since it consolidates the knowledge and competencies viewed globally as essential for 15-year-old learners to survive in different situations in the 21st century.

In every cycle of PISA, OECD highlights one literacy area among the three major assessment areas such as mathematics, science, and reading. In 2018 PISA, the first PISA cycle that the Philippines participated in, reading literacy was highlighted. This means reading has more items in the assessment compared to the mathematics and scientific literacies. However, in PISA 2021, mathematics is the highlight and so it is expected to have more items than those for science and reading literacies. OECD released to the public in November 2018 its draft framework for PISA 2021 mathematics literacy. This document was examined in this study as it is considered the most recent international benchmark in setting the desired knowledge and competencies that JHS students should acquire when they reach the age of 15. Figure 1 shows the PISA 2021 Mathematics Framework.

Figure 1

OECD PISA 2021 Mathematics Framework (Adopted from OECD, https://pisa2021-maths.oecd.org)



As shown in Figure 1, PISA Mathematics looks into several dimensions of what it means to be mathematically literate. In the context of PISA, mathematics literacy is defined as follows:

> 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)

In assessing mathematics literacy, every item could provide four information since there are four different dimensions covered as shown in Figure 1. These dimensions are the core mathematical skills, content domain, context domain, and the 21st century skills.

The *first dimension* refers to the **core mathematical skills**. There are two core mathematical skills needed to define a mathematically literate 15-year-old learner. These are mathematical reasoning and problem solving. In PISA 2021, *mathematical reasoning* refers to one's ability to present reasons or arguments in a convincing way or to draw impartial conclusions without need for external validation (OECD, 2018). There are at least six (6) key understandings that provide structure to mathematical reasoning. These include understanding quantity, number systems, and their algebraic properties; appreciating the power of abstraction and symbolic representations; seeing mathematical structures and their regularities; recognizing functional relationships between quantities; using mathematical modelling as a lens onto the real world (e.g. those arising in the physical, biological, social, economic and behavioral sciences); and understanding variation as the heart of statistics. Mathematics reasoning involves three processes of *problem solving*, namely: *formulating; employing; and interpreting and evaluating* (OECD, 2018).

The *second dimension* is the **content domain**. There are four categories for content domains in PISA Mathematics since its inception. These are: 1) change and relationships; 2) space and shape; 3) quantity; and 4) uncertainty and data. *Space and Shapes* category 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, functions concepts, measurement and geometry software, and geometric approximations (OECD, 2018). *Change and Relationships* category involves functions and algebra, algebraic expressions, equations and inequalities, tabular and graphical representations, data representations using statistics, geometric measurement, and growth phenomena (OECD, 2018). *Quantity* category includes the

quantification or measurement of the attributes of objects or entities in the world; their representations and interpretations, and an understanding of numerical trends and patterns, mental computations and estimation, assessment of uncertainties including computer simulations (OECD, 2018). *Uncertainty and Data* category includes recognizing the place of variation in the real world, including having a sense of quantification of that variation, and acknowledging its uncertainty and error in related inferences. It also includes forming, interpreting, and evaluating conclusions drawn in situations where uncertainty is present (OECD, 2018).

In PISA 2021 (OECD, 2018), there are 18 content topics with special emphasis on four new topics, namely: growth phenomena (change and relationships); geometric approximation (space and shape); computer simulations (quantity); and conditional decision making (uncertainty and data). *Growth phenomena* topic requires understanding of situations that demand people to think of data not only in terms of linear relationship but also in non-linear or exponential relationships like in the study of the spread of the disease in flu pandemic and bacterial outbreaks. *Geometric approximations* topic requires the students to use their 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 easily addressed like budgeting, saving, experimental probability, and population distribution where computer simulations are used as a tool for decision making. *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; co-ordinate 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).

The *third dimension* is the **context domain**. The context is where the problems that need mathematical content knowledge and skills are applied in a wide variety of real-life personal to global contexts. There are four types of contexts where mathematical content and skills or where problems are applied and these are from *personal* (e.g., personal activities, family and peers, etc.); *occupational* (i.e., job-related concerns like payroll, quality control, etc.); *societal* (i.e., problems that may involve local, national or global concerns like public transport, government, policies, etc.); and *scientific* (i.e., problems related to science and technology like weather, ecology, medicine, etc.) (OECD, 2018). If an item measures a construct specific to mathematics, it is categorized under scientific.

The *fourth and last dimension* are the **21st century skills** that are valued in PISA 2021, which are embedded in the assessment of mathematics literacy. These 21st century skills include critical thinking; creativity; research and inquiry; self-direction, initiative, and persistence; information use; systems thinking; communication; and reflection (OECD, 2018). These skills are expected to be infused in the teaching of mathematics for the students to make independent judgments and take responsibility for them. These 21st century skills are both an outcome of and focus for mathematics (OECD, 2018).

The PISA assessment 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 selected-response (multiple choice) and constructed-response (closed and open) test formats.

The analysis of PISA mathematics literacy framework vis-à-vis the mathematics component of the CHED-mandated program for Bachelor of Secondary Education (BSEd) major in mathematics is necessary to know how well this teacher education program prepares would-be mathematics teachers in developing the thinking processes, content knowledge, and 21st century skills of junior high school students that are applied in various contexts.

Innovative Assessment Areas in PISA

In every cycle of PISA, there is an innovative assessment area introduced. In 2012, 2015, 2018 and even in 2021 PISA, financial Literacy was introduced as an innovative assessment area. It was offered every cycle as an optional assessment integrated with the major areas such as mathematics, science and reading. In 2015, collaborative problem solving was introduced. This was based on the individual problem solving skills introduced in PISA 2012. Collaboration is an important 21st century skill together with problem solving and so in PISA 2015, the innovative area introduced was collaborative problem solving skill. In 2018, global citizenship was introduced. In 2021, creative thinking is the focused innovative area. Three of these four PISA innovative assessment areas such as financial literacy, collaborative problem solving, and creative thinking were also analyzed in this study to find out the extent to which the BSEd major in mathematics program responds to the challenges they posed as they relate to mathematics literacy as defined in PISA.

Financial Literacy

One innovative assessment area in PISA introduced starting 2012 is Financial Literacy, defined as follows:

> Financial literacy is knowledge and understanding of financial concepts and risks, as well as the skills and attitudes to apply such knowledge and understanding in order to make effective decisions across a range of financial contexts, to improve the financial well-being of individuals and society, and to enable participation in economic life. (OECD, 2019, p.18)

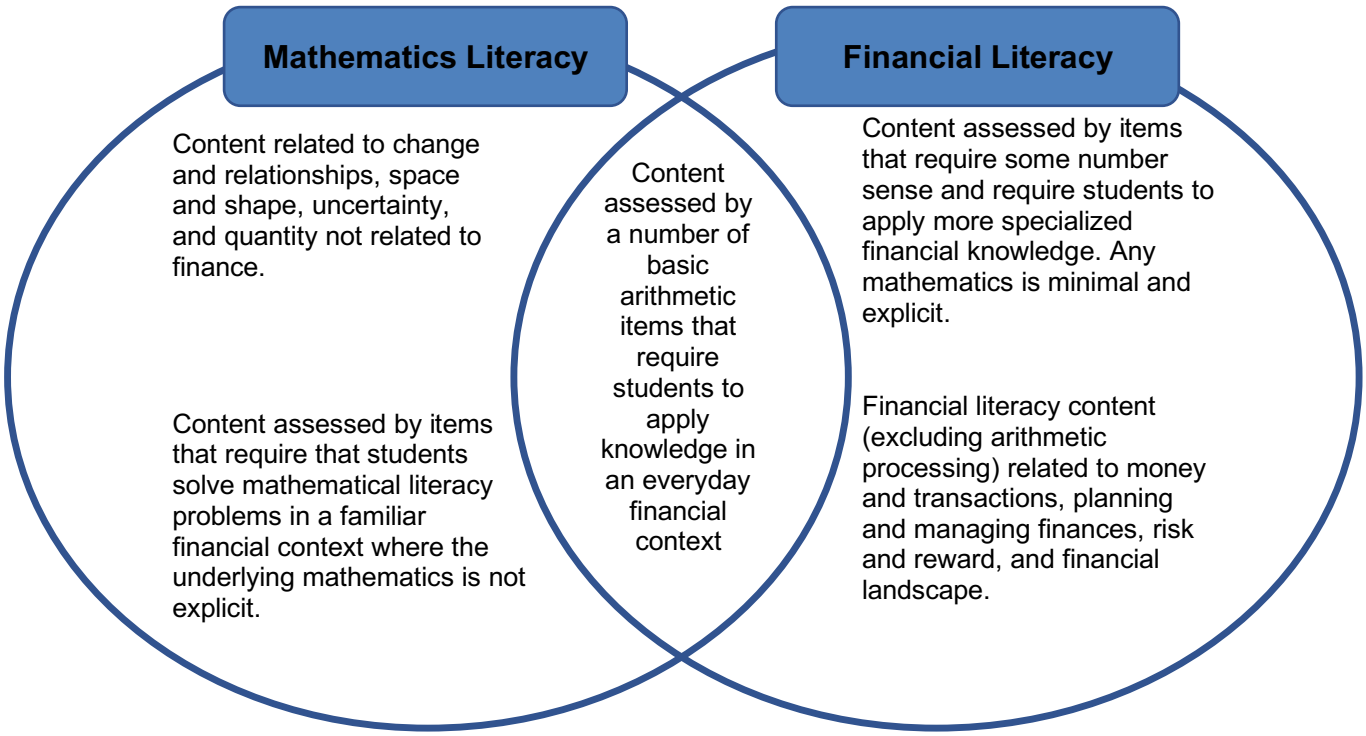
Financial literacy is viewed globally as an essential skill as it is an important element of economic and financial stability and development (OECD, 2019). It is believed that a person who lacks financial literacy makes ill-informed financial decisions that could have an adverse effect on both personal and global resilience (OECD, 2009, 2018). Moreover, studies show that young people and adults in both developed and emerging economies who have been exposed to good quality financial education are subsequently more likely than others to plan ahead, save, and engage in other responsible financial behaviors (Amigar et al., 2018; Atkinson et al., 2015; Bruhn et al., 2016; Kaiser & Menkhoff, 2016; Miller et al., 2014 cited in OECD, 2019). There are also studies showing that 15-year-old students with bank accounts have higher levels of financial literacy than those without bank accounts on average across the OECD countries participating in 2012 and 2015 PISA exercise (OECD, 2017; OECD, 2014 cited in OECD, 2019). Financial education was introduced to youth and in schools in 2005 (OECD, 2019, p123) but the PISA Financial Literacy Assessment in 2012 contributed to the formulation of Core Competencies Framework on Financial Literacy for Youth (OECD, 2019).

In the PISA Financial Literacy Framework, there are three domains covered. These are the content, process, and context domains. The ***content domain*** tells the knowledge and understanding that 15-year-old learners need to know to perform a particular task involving financial literacy. The four content areas in PISA financial literacy that are viewed common around the globe are: 1) *money and transactions; 2) planning and managing finances; 3) risk and reward; and 4) financial landscape*. The ***process domain*** refers to the cognitive processes that could describe if the 15-year-old learners can recognize and apply concepts relevant to financial literacy. The four processes in PISA Literacy framework are: 1) *Identify financial information; 2) Analyse financial information and situations; 3) Evaluate financial issues; and 4) Apply financial knowledge and understanding.* The ***context domain*** refers to the range of situations where a 15-year-old learner needs to function in the 21st century. The four contexts domains are: *1) education and work; 2) home and family; 3) individual; and 4) societal.*

The OECD PISA Financial Literacy framework is distinct from the PISA mathematics framework. PISA Financial Literacy framework acknowledges, however, the need for mathematics literacy applied in different financial contexts. Figure 2 shows how mathematics literacy relates to financial literacy.

Figure 2

Relationship between the content of Financial Literacy and Mathematics Literacy in PISA 2021 (Adopted from OECD, 2019, p. 41)



As shown in Figure 2, financial literacy has common area of concern with that of mathematics literacy and that is its need for the content of q*uantity,* particularly knowledge and skills in basic arithmetic, like calculation of percentages applied in everyday financial context. Financial literacy, however, is distinct from mathematics literacy in some areas where content knowledge focuses on the four financial matters (i.e. money and transactions; planning and managing finances; risk and reward; and financial landscape) that do not involve arithmetic. In contrast, in mathematics literacy, there is a focus on mathematical content (i.e. change and relationships; space and shape; uncertainty and data; and quantity) not related to finance.

Given the emphasis on financial education and its assumed contribution to improving the life of an individual including its country, there is a need to integrate

financial literacy as well in the preparation of would-be mathematics teachers. Since financial literacy is supposed to be integrated in all disciplines including mathematics, it is good to examine how responsive the BSEd curriculum for mathematics major is to the financial literacy competencies set in PISA. Since a certain level of mathematical literacy is regarded a necessary condition of financial literacy (OECD, 2019), then such analysis of financial literacy framework vis-à-vis the BSEd mathematics curriculum is necessary. As Housten (2010) cited in OECD (2019) explains, if an individual struggles in arithmetic skills, this will certainly impact his/her financial literacy.

Collaborative Problem Solving

One innovative area introduced in PISA 2015 is collaborative problem solving (CPS), which is an improvement of individual problem solving in PISA 2012. The OECD (2017) sees CPS as an important and necessary skill in the 21st century where individuals pool their understanding and resources together to solve a problem. It is defined as follows:

> Collaborative problem-solving is the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution. (OECD, 2017, p.134)

As most of the problem solving activities in the world are carried out in teams, students need to prepare for careers that need the ability to work effectively in groups and to apply problem solving in these social situations. CPS is considered more advantageous than individual problem solving as "it requires effective division of labor; incorporation of ideas from multiple perspectives, experiences, and sources of knowledge; and enhancement of creativity and quality of solutions stimulated by the ideas of the members of the group" (OECD, 2017, p.132). As there is a growing emphasis in the use of project-based and inquiry-based learning, there is a need for a curriculum that emphasizes problem solving and collaboration skills aside from critical thinking and communication. This led to the inclusion of collaborative problem solving as an innovative area introduced in PISA 2015. This skill is not linked to just one particular subject as it is supposed to be integrated in all areas and levels but is expected most specially in science, mathematics, and history (OECD, 2017).

The PISA Collaborative Problem Solving Framework integrates four individual ***problem solving processes*** considered *as cognitive processes* and three ***collaboration processes*** considered as *social processes*. The problem solving processes as identified in PISA 2012 are: A) exploring and understanding; B)

representing and formulating; C) planning and executing; and D) mentoring and reflecting (OECD, 2010; OECD, 2017). Collaborative processes, on the other hand are: 1) establishing and maintaining shared understanding; 2) taking appropriate action to solve the problems; and 3) establishing and maintaining team organization (OECD, 2017). The Collaborative Problem Solving Framework then have 12 competencies drawn from the integration of the three major collaborative problem-solving competencies and four individual problem solving processes. Table 1 shows the 3x4 matrix integrating the three collaborative processes and four individual problem solving processes. This matrix tells the 12 competencies that could capture the whole essence of collaborative problem solving skills in PISA 2015 (OECD, 2017, p.137) .

Table 1

Matrix of Collaborative Problem Solving Skills for PISA 2015 (Adopted from OECD, 2017, p. 137)

Collaborative Problem Solving Skills	**1) Establishing and maintaining shared understanding**	**2) Taking appropriate action to solve the problems**	**3) Establishing and maintaining team organization**
A) Exploring and understanding	(A1) Discovering perspectives and abilities of team members	(A2) Discovering the type of collaborative interaction to solve the problem, along with goals	(A3) Understanding roles to solve the problem
B) Representing and formulating	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	(B2) Identifying and describing tasks to be completed	(B3) Describing roles and team organization (communication protocols/rules of engagement)
C) Planning and executing	(C1) Communicating with team members about the actions to be/being performed	(C2) Enacting plans	(C3) Following rules of engagement (e.g., prompting other team members to perform their tasks)
D) Mentoring and reflecting	(D1) Monitoring and repairing the shared understanding	(D2) Monitoring results of actions and evaluating success in solving the problem	(D3) Monitoring, providing feedback and adapting the team organization and rules

Creative Thinking

Creative Thinking is another area introduced in PISA as it drives innovation that has world-wide impact. It is considered a tangible and essential competence that is grounded in knowledge and practice that supports individuals in achieving better outcomes, oftentimes in constrained and challenging situations (OECD, 2019). In PISA 2021, *creative thinking* is defined as the "competence to engage productively in the practice of generating ideas, how to reflect upon ideas by valuing both their relevance and novelty, and how to iterate upon ideas until they reach a satisfactory outcome" (OECD, 2019, p.8). It can improve a lot of individual abilities including metacognitive capacities, inter-and intra-personal and problem solving skills (OECD, 2019, p.5).

Creative thinking can help young people to undertake work that cannot be easily replicated by machines and other increasingly complex local and global challenges with-out-of-the-box solutions (OECD, 2019). It can be developed as one acquires content knowledge through exploration and discovery and not through rote learning and automation (Beghetto et al., 2015 cited in OECD, 2019). It is a construct that is linked to "divergent thinking as it requires production of original ideas by forming unexpected combinations from available information and by applying abilities such as semantic flexibility and fluency of association, ideation and transformation" (Cropley, 2006 cited in OECD, 2019, p.12). It is an emerging construct under a broader concept of *creativity,* which is a multidimensional and social construct involving interaction among aptitude, process, and environment by which an individual or group produces a perceptible useful and novel product within a social context (OECD, 2019). Creative thinking is built upon a confluence of approaches recognizing student's internal resources (e.g. cognitive skills, goal orientation) and nurturing environment (e.g. classroom culture, educational system) (OECD, 2019).

There are two ways to look at creativity, the big C, which is associated with technology breakthroughs or art masterpieces that demand creative thinking paired with significant talent, deep expertise, and high level of engagement in a particular area with recognition from the society of its value. The other type of creativity is the "little c", which refers to everyday creativity that can be achieved by nearly all people capable of engaging in creative thinking. Examples of tasks that are done by the "small c" of creativity are combining leftovers to make a tasty meal or arranging family photos in a scrapbook (Kaufman & Beghetto, 2009 cited in OECD, 2019, p.9). The "little c" creativity can be done through practice and education. PISA 2021 focuses on the "little c" creativity as it believes in the capacity of the individual to engage in creative thinking that is not due to innate talent but due to education (OECD, 2019).

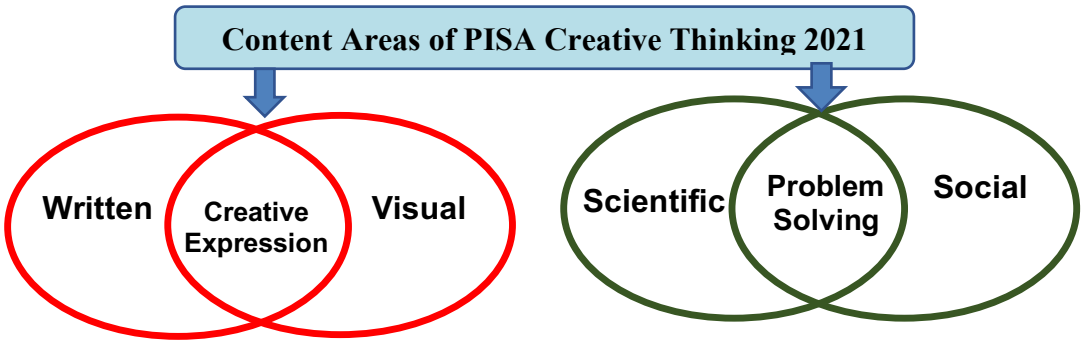
PISA 2021 creative thinking has two broad thematic **content areas**: *creative expression* and *knowledge creation and creative problem solving* (See Figure 3).

Creative expression refers to "instances where creative thinking involves communicating one's inner world to others" (OECD, 2019, p. 19). This thematic content domain is divided into written and visual expression. Originality, aesthetics, imagination, and affective intention and response largely characterize creative engagement in these domains. *Written expression* is a way of communicating one's imagination (fiction and nonfiction) in a written format following rules and conventions for understandable communication. Examples of written expression include slogans and tag-lines. *Visual expression* involves communication of ideas using a range of media, materials and processes (Irish National Teacher Association, 2009, cited in OECD. 2019, p. 20-21). Examples of visual expression include engagement in an open visual design task that requires digital drawing tools.

Knowledge creation and creative problem solving is a creative engagement that "involves a more functional employment of creative thinking that is related to the investigation of open problems or questions where there is no single solution" (OECD, 2019, p.19). This content domain is divided into *scientific problem solving* and *social problem solving*. Creative thinking in these domains require generating solutions that are original, innovative, and effective (OECD, 2019, p.19). Figure 3 shows the content domains of creative thinking in PISA 2021.

Figure 3

Content Domains of Creative Thinking in PISA 2021 (Adopted from OECD, 2019)

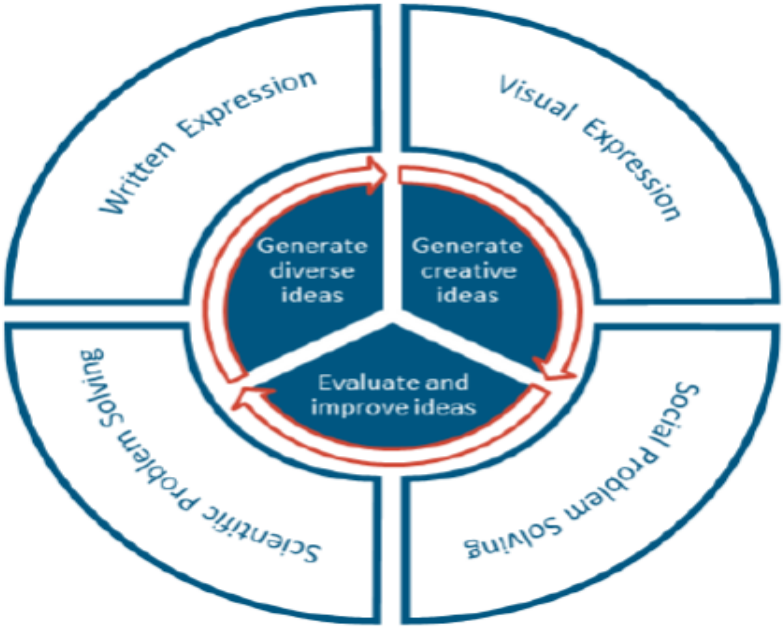


As shown in Figure 3, creative problem solving can be scientific and social. *Scientific problem solving* can be related to scientific inquiry skills focused on generation of new ideas, originality of approaches and solutions, openness to problems that have multiple possible solutions but with no clear optimal solution, and creative thinking in scientific contexts. *Social problem solving* refers to creative thinking that involves generation of solutions to social problems or suggesting original improvements to problem solutions (OCED, 2019).

PISA 2021 creative thinking assessment focuses on three facets of competencies: generate diverse ideas; generate creative ideas; and evaluate and improve ideas (See Figure 4) (OECD, 2019). *Generate diverse ideas* is a competency associated not only with the number of new ideas generated (i.e. ideation fluency) but more on the diversity of these ideas (i.e. ideation flexibility) and avoidance of functional fixedness in the idea generation process. *Generate creative ideas* refers not only with the intention but more importantly with the outcome such that it ends with a tangible creative product or idea that is considered both novel (i.e. remote, unusual, original and deviance from others) and useful (i.e. a solution to a problem). *Evaluate and improve ideas* refers to the capacity to identify limitations and find original ways to improve them or an act in providing feedback on the strengths and weaknesses of others' ideas to improve the creative outcome (i.e. reshaping an innovative idea).

Figure 4

Competency Model for the PISA 2021 Creative Thinking Framework (Adopted from OECD,2019, p.23)



As shown in Figure 4, the three competencies of PISA creative thinking should be seen in content domains of visual and written creative expression as well as in social and scientific problem solving. They were studied as to how they were aligned with the teacher education for mathematics program as all subject areas should be a venue for the development of such 21st century skills. Since creative thinking includes the creative problem solving domain and mathematics is known as a venue for the development of problem solving skills, it would be good to examine if mathematics

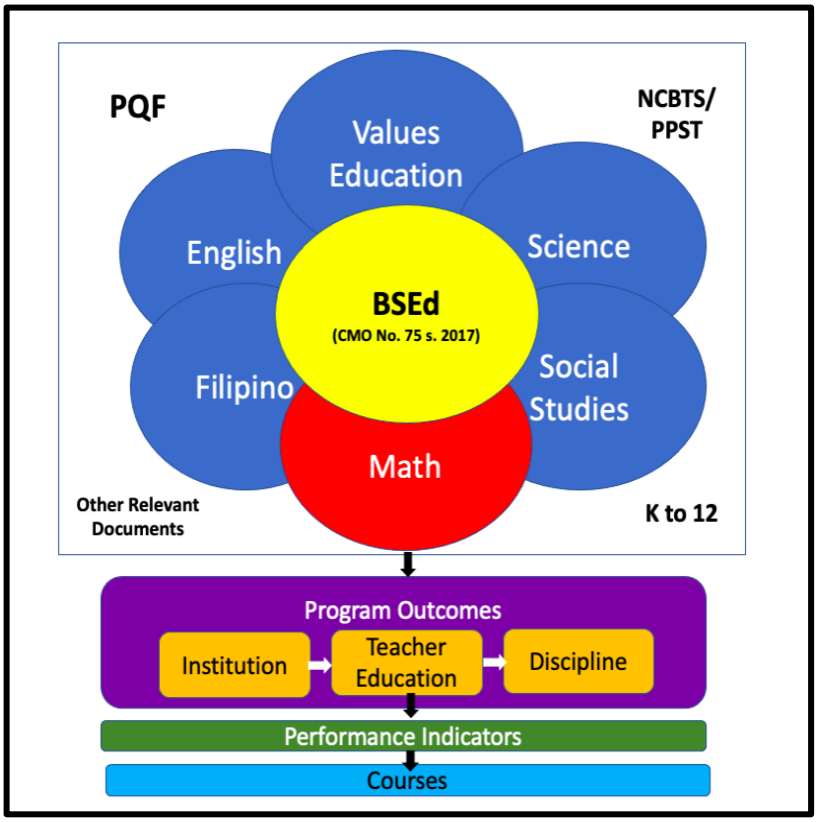
teachers are prepared to be good not only at mathematics literacy but also at collaborative and creative problem solving skills as well.

Framework of the Mathematics Teacher Education Program

The framework of mathematics teaching in the teacher education program could be drawn from the CHED Memorandum Order (CMO) No. 75, series of 2017. The said CMO covers the policies, standards, and guidelines in the implementation of the outcome-based BSEd program where one of the majorship areas is Mathematics. The BSEd program aims to develop highly motivated and competent teachers in the secondary level. As CHED sets outcome-based education program, BSEd is structured to have program outcomes common to any bachelor's degree and any teacher education program but with specific program outcomes to a specialization program like the BSEd Major in Mathematics program. Figure 5 shows the structure of the BSEd program.

Figure 5

Framework of the Teacher Education Program for Bachelor of Secondary Education (BSEd)



As shown in the Figure 5, the BSEd Major in Mathematics, just like the other specialization areas such as English, Filipino, Science, Social Studies and Values Education, is shaped by different drivers to include the Philippines Qualifications Framework (PQF), the National Competency-based teacher Standards (NCBTS) now called the PPST, the Kto12 Program, and other relevant documents (CHED, 2017). It is expected that the program produces mathematics teachers who can demonstrate the desired outcomes of the graduates of the BSE Mathematics program.

The graduates of the BSEd program are expected to attain the minimum of five **program outcomes** that are true to all **bachelor's degree programs** or programs at PQF level 6 and these are to: 1) articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor); 2) effectively communicate in English and Filipino, both orally and in writing; 3) work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor); 4) act in recognition of professional, social, and ethical responsibility; and 5) preserve and promote "Filipino historical and cultural heritage (based on RA 7722).

Moreover, the BSEd has a minimum of eight **program outcomes for teacher education,** which the specialization in Mathematics and all other areas also target. They are as follows: 1) articulate the rootedness of education in philosophical, socio-cultural, historical, psychological, and political contexts; 2) demonstrate mastery of the subject matter/discipline; 3) facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment; 4) develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners; 5) apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices; 6) demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes; 7) practice professional and ethical teaching standards sensitive to local, national, and global realities; and 8) pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities.

In the BSEd program, there are six majorship areas to include English, Filipino, Science, Social Studies, Values Education and Mathematics (See Figure 5). For the BSEd Mathematics, there are seven **discipline-specific program outcomes** targeted for each graduate and they are as follows: 1) exhibit competence in mathematical concepts and procedures; 2) exhibit proficiency in relating mathematics to other curricular areas; 3) manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics; 4) demonstrate competence in designing, constructing, and utilizing different forms of assessment in mathematics; 5) demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity; 6) use effectively appropriate

approaches, methods, and techniques in teaching mathematics including technological tools; and 7) appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery, and gaining insights of the world.

In each of the program outcomes of BSEd Mathematics, there are two to five performance indicators. These performance indicators are expected to be attained in mathematics courses that are offered in the General Education and Specialization courses. There is only one 3-unit course in Mathematics under the General Education and that is *Mathematics in the Modern World*. There are 20 specialization courses in Mathematics with a total of 63 units. 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 CMO No. 75 s, 2017 provides the course description of each course (See Appendix A for the course description of these courses). The course description of these courses in BSEd Mathematics were examined in relation to the mathematics literacy, financial literacy, collaborative problem solving, and creative thinking frameworks of PISA.

Conceptual Framework

The study aims to examine the level of responsiveness of the BSEd Major in Mathematics program on the challenges of PISA mathematics literacy, financial literacy, collaborative problem solving, and creative thinking. PISA is designed to assess three major literacies to include mathematics aside from reading and science. For PISA 2021, mathematics literacy is the emphasis among the three major literacy areas while creative thinking is highlighted among the innovative assessment areas. Financial Literacy remains an optional assessment area in all cycles of PISA since 2012. As the PISA sets the world expectations for the 15-year-old learners, the Philippines that subscribes to it should then use its results to inform its education program not only in basic education but in teacher education as well.

Among the teacher education programs that should be informed by the challenges of PISA is the BSEd program as it prepares teachers to deliver the secondary education curriculum where these 15-year old learners belong. In the OECD Report of PISA 2018, the 15-year-old learners sampled were in their Grade 9, 10 and 11 in the secondary education program (OECD, 2019). For the Philippines,

these same grade levels were where the 15-year-old Filipino learners were sampled but the modal grade was Grade 9 (OECD, 2019; DepEd, 2019).

As the Republic Act No.10533 or known as Enhanced Basic Education Act in 2013 mandates, the country has to continuously gather indicators of the effectiveness of the Enhanced Basic Education Program that has been introduced in the Philippines since 2013. As the Enhanced Basic Education Program aims for the Filipino learners to be holistically developed and equipped with 21st century skills that will make them globally competitive, the teacher education program that produces the teachers who train and mold these globally competitive learners will have to be examined as well if it meets global standards. As the country's participation in PISA starting 2018 indicates adherence to the global standards set in this ILSA for 15-year-old learners, it implies that the teacher education program should likewise consider the merit of the same standards in its design so that would-be teachers will be able to develop the same skills expected of the learners.

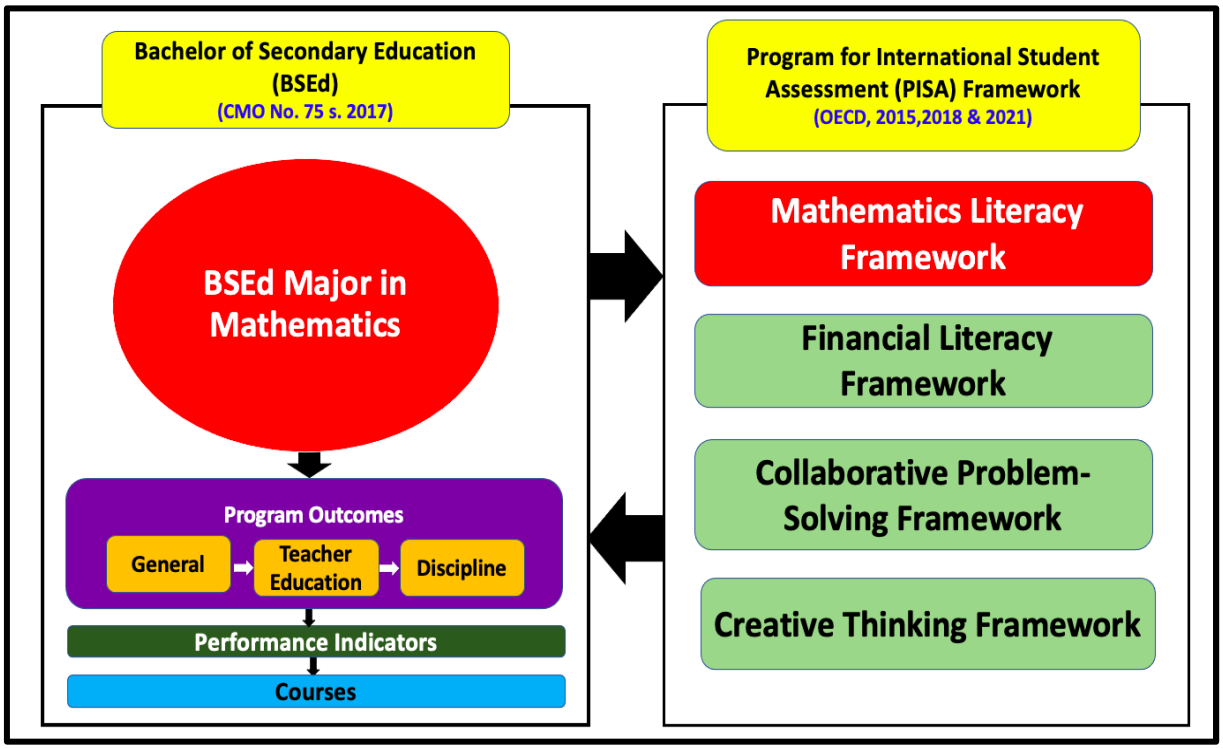
It is at this juncture that this study was conducted to examine how responsive the teacher education program is in meeting the demands of PISA to 15-year-old learners. The general program outcomes for any bachelor's degree and any teacher education as well as those specific to the discipline of BSEd Major in Mathematics were examined if they capture the challenges and directions of PISA mathematics literacy. The performance indicators as well as the course offerings with their course descriptions for the BSEd Mathematics were analyzed if they capture the processes, content, context, and 21st century skills that are emphasized in PISA 2021 mathematics framework.

As PISA also assesses some innovative areas such as financial literacy, collaborative problem solving, and creative thinking, the content, processes and contexts in these assessment areas were also examined as to how they are embodied in the BSEd Major in Mathematics program.

Figure 6 shows what this study intends to cover. As shown in the figure, the study aims to examine the responsiveness of the BSEd program for mathematics majors in meeting the demands of PISA mathematics literacy, financial literacy, collaborative problem solving, and creative thinking since the Philippines participates in it to gather possible indicators of the effectiveness of the Kto12 Reform. The analysis of the general and specific program outcomes as well as performance indicators and courses in terms of their alignment with the components of the PISA assessment areas could inform the needed improvements in the BSEd program.

Figure 6

Analysis of the BSEd Mathematics Program vis-à-vis PISA Mathematics Literacy, Financial Literacy, Collaborative Problem Solving, and Creative Thinking Frameworks



Statement of Purpose

The study aims to examine how responsive the BSEd Major in Mathematics program is in meeting the demands of PISA as one source of the indicators of the effectiveness of the K to 12 program. It is assumed that the BSE mathematics program has been designed to respond to the needs of the Kto12 program and to meet global standards such as those set in PISA for the 15-year-old learners. Hence, this study aims to test such assumption. In particular, the study seeks to answer the following questions:

1. 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 the demands of PISA in the following areas of assessment?
    a. mathematics literacy
    b. financial literacy

c. collaborative problem solving
d. creative thinking

2. What improvements are recommended in the BSEd Major in Mathematics program to meet the demands of PISA?

METHODOLOGY

This section describes the research design, participants, instrumentation, data gathering procedure, and data analysis of this study.

Research Design. The study is a qualitative-descriptive research which makes use of document and content analysis to describe the responsiveness of the teacher education program for mathematics teachers in secondary schools on the demands and challenges of PISA 2021 Mathematics Literacy, Financial Literacy, Collaborative Problem Solving, and Creative Thinking Frameworks. The official documents that were examined in this study are the OECD released PISA 2021 Mathematics Framework in November 2018, the 2021 Financial Literacy Framework released in April 2019, the 2015 Collaborative Problem Solving released in 2017, and 2021 Creative Thinking Framework released in April 2019. All these PISA Frameworks are made available in OECD website. Likewise, the CHED Memo No. 75, s 2017 which sets the PSGs of the BSEd Major in Mathematics program, which is also available in CHED's website was also analyzed.

Participants of the Study. Since the conduct of this study is a product of a sabbatical leave applied by the researcher, which does not have any funding support except her own salary, she had to be the sole analyst of the documents. However, to ensure the acceptability of the process and product of her analysis, it was subjected to peer reviews by three educators who are doctorate degree holders and recognized mathematics education specialists from her University and who have taught mathematics in teacher education program for at least 14 years and at most 37 years. These educators chosen to review her report have also done an analysis of the PISA 2021 mathematics framework vis-à-vis the Kto12 curriculum upon the release of the PISA 2018 results in December 2019. The educators' reviews served as the basis in the revision and finalization of the researcher's analysis of the documents. The researcher analyzed and compared all the reviews of the three reviewers. She followed the suggestions of each of the three reviewers that she agree with. In areas where she had disagreements with the reviews, she followed her own analysis with

justification of her decision (Please refer to Appendix B to D for the comments of the reviewers and the action taken by the researcher).

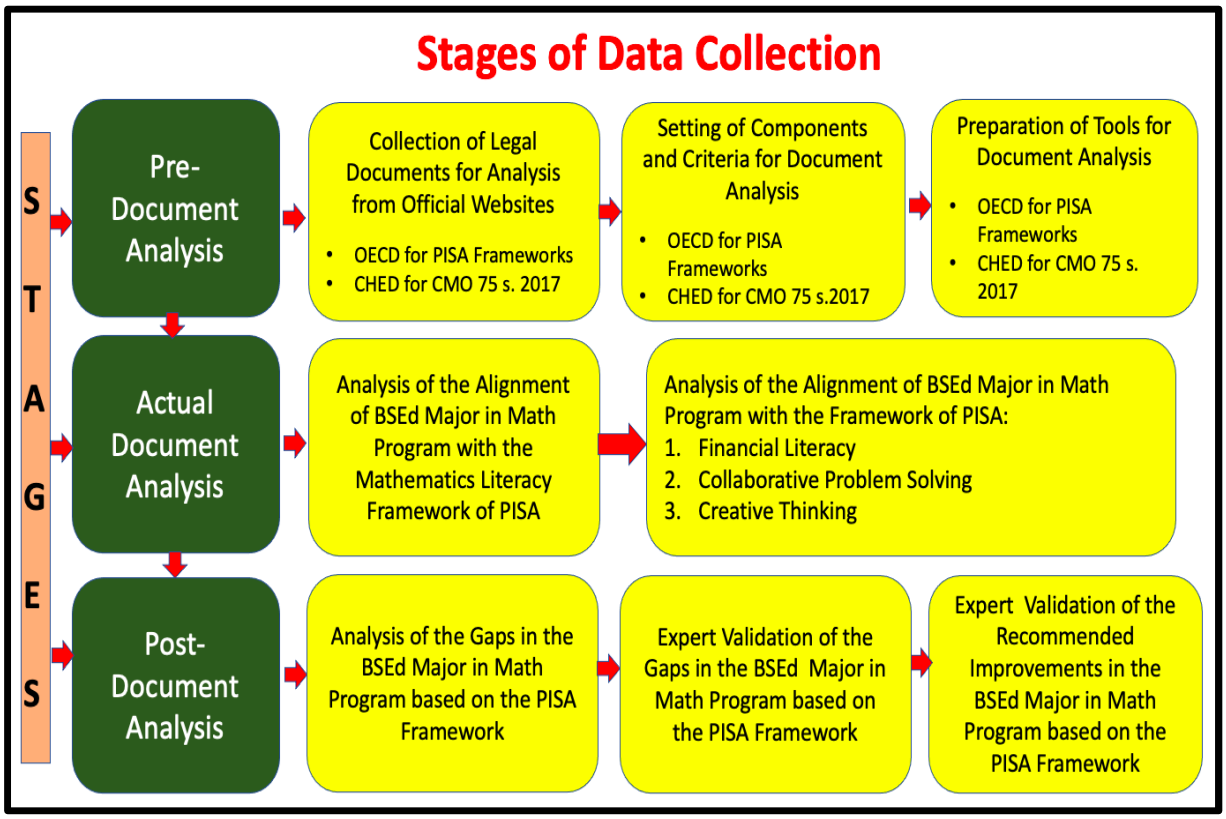
Instrumentation. The researcher prepared a matrix for analysis that shows the key components of the PSGs for the BSEd Major in Mathematics *(See Appendix A).* This matrix reflects the codes she used for the program outcomes common for all bachelor's degree (i.e. general), for teacher education programs, and for BSEd Major in Mathematics. The matrix also shows the performance indicators that correspond to each program outcome in BSEd mathematics, the courses offered and their units and their course description. This set of information in the matrix were mapped repeatedly to each of the components of the framework of PISA mathematics literacy, financial literacy, collaborative problem solving, and creative thinking. As the matrix provides information that were directly lifted from the CMO No.75 s. 2017, no validation on the matrix was needed.

Data Gathering Procedure. The study underwent three stages: Pre-document analysis; actual document analysis; and post-document analysis (See Figure 7). The *pre-document analysis* includes processes such as collecting official documents from OECD and CHED websites, identifying the components of the PISA and BSEd frameworks for analysis, and preparing the tool for document analysis. *Actual document analysis* includes examining the alignment of the BSEd Major in Mathematics program with PISA 2021 Mathematics Literacy Framework and the other three (3) PISA innovative assessment areas (financial literacy, collaborative problem solving, and creative thinking). *Post-data analysis* includes the validation of the alignment and gaps of the documents analyzed and the recommended improvements in the BSEd major in mathematics program to address identified gaps based on the PISA frameworks.

Data Analysis. As the data are mostly qualitative with the simple matching of the information that are common in both documents, a simple frequency count with conversion into percentage was done to determine the degree of responsiveness of the BSEd mathematics in producing the would-be teachers in secondary schools that could develop the mathematics literacy and other PISA-related literacies expected of mathematics teachers. Actual quotation from documents was done to illustrate the explicit alignment between documents analyzed. The researcher did the mapping of the documents using her professional judgment of the alignment of the components of the documents perused, she being a Mathematics Education specialist herself.

Figure 7

Stages in the Document Analysis



RESULTS AND DISCUSSION

1. Alignment of the BSEd Major in Mathematics Program to PISA Mathematics Literacy Framework

1.1 PISA Mathematics Literacy Framework

The results of the analysis of the researcher on the alignment of the core competencies in PISA 2021 Mathematics Framework vis-à-vis the program outcomes, performance indicators, and courses set in the BSEd Major in Mathematics are described in detail in Tables 1.1 to 1.4. The specific PISA competencies for the reasoning and problem solving processes are shown in these tables. Then Tables 1.5 to 1.8 show the program outcomes common in a bachelor's degree and teacher education program outcomes, mathematics program outcomes, and mathematics performance indicators defined in the BSEd Major in Mathematics and their alignment with PISA 2021 Mathematics Framework. Two-pronged analyses were made, one from the lens of PISA 2021 (i.e. Table 1.1 to 1.4) and then from the lens of the BSEd Mathematics (i.e. Table 1.5 to 1.8). Such analyses were made to give a better picture of how the two documents align with one another .

1.1.1 Alignment of the PISA Mathematics Core Processes with BSEd Major in Mathematics Program Outcomes and Performance Indicators

a. PISA Mathematics Reasoning Processes

Table 1.1 shows that there are 18 **reasoning processes** that are expected of a mathematically literate 15-year-old learner and how they are covered in the program outcomes and performance indicators of the BSEd Major in Mathematics program (See also Table 1.5 to 1.8). It can be gleaned from the table that there are only two (2) ***general program outcomes*** that could already cover the 18 PISA reasoning processes. Reasoning processes require effective communication either in English or Filipino in oral or written form. This explains why 14 of the reasoning processes that require explaining, justifying, analyzing or drawing conclusions are already covered by just the general 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.

In terms of the ***program outcomes in teacher education***, the statement that says that the graduates are expected to "demonstrate mastery of the subject matter/discipline (CMOPOTE22)" is broadly stated that it could already cover all the 18 reasoning processes in PISA mathematics literacy framework. It is also the most related among the eight (8) statements of program outcomes to capture the PISA reasoning processes.

In terms of the BSEd Major in Mathematics ***specific program outcomes***, three (3) 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 (6) of the reasoning processes; 2) Exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers eight (8) 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 (4) of the processes.

Lastly, in terms of ***performance indicators in mathematics***, five (5) indicators could capture the 18 reasoning processes in PISA and these are: 1) Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed (CMOPOTEPIM3311); 2) Demonstrate in detail basic mathematical procedures (CMOPOTEPIM3312); 3) Demonstrate skills in various methods of learning in mathematics such as conducting investigations, modeling, and doing research (CMOPOTEPIM3331); 4) Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking (CMOPOTEPIM3332); and 5) Demonstrate skills in various problem solving heuristics (CMOPOTEPIM3351).

Table 1.1

*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	CMOPOTEM331	CMOPOTEPIM3332
R2	Select an appropriate justification	CMOPOG12	CMOPOTE22	CMOPOTEM331	CMOPOTEPIM3332
R3	Explain why a mathematical result or conclusion does, or does not, make sense given the context of a problem	CMOPOG12	CMOPOTE22	CMOPOTEM331	CMOPOTEPIM3311
R4	Represent a problem in a different way, including organizing it according to mathematical concepts and making appropriate assumptions	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
R5	Utilize definitions, rules and formal systems as well as employing algorithms and computational thinking	CMOPOG11	CMOPOTE22	CMOPOTEM331	CMOPOTEPIM3312
R6	Explain and defend a justification for the identified or devised representation of a real-world situation	CMOPOG12	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3331
R7	Explain or defend a justification for the processes and procedures or simulations used to determine a mathematical result or solution	CMOPOG12	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3312
R8	Identify the limits of the model used to solve a problem	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
R9	Understand definitions, rules and formal systems as well as employing algorithms and computational reasoning	CMOPOG11	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3312
R10	Provide a justification for the identified or devised representation of a real-world situation	CMOPOG12	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3331
R11	Provide a justification for the processes and procedures used to determine a mathematical result or solution	CMOPOG12	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3312
R12	Reflect on mathematical arguments, explaining and justifying the mathematical result	CMOPOG12	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3332
R13	Critique the limits of the model used to solve a problem	CMOPOG12	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
R14	Interpret a mathematical result back into the real-world context in order to explain the meaning of the results	CMOPOG12	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3311
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	CMOPOTEM333	CMOPOTEPIM3311
R16	Reflect on mathematical solutions and create explanations and arguments that support, refute, or qualify a mathematical solution to a contextualized problem	CMOPOG12	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
R17	Analyse similarities and differences between a computational model and the mathematical problem that it is modelling	CMOPOG12	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3331
R18	Explain how a simple algorithm works and to detect and correct errors in algorithms and programs	CMOPOG12	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3312

b. PISA Mathematics Formulating Processes

Table 1.2 shows the **formulating processes** that are expected of a mathematically literate 15-year-old learner and how they are covered in the program outcomes and performance indicators of the BSEd Major in Mathematics program (See also Table 1.5 to 1.8). It can be gleaned from the table that there is only one (1) ***general program outcome*** that could already cover the 12 PISA formulating processes and this is stated as "articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11)."

In terms of the ***program outcomes in teacher education***, the statement that says that the graduates are expected to "demonstrate mastery of the subject matter/discipline (CMOPOTE22)" could already cover all the ten (10) formulating processes. The other teacher education program outcome that covers two formulating processes is "apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable (CMOPOTE25)."

In terms of the ***BSEd Major in Mathematics specific program outcomes***, three (3) outcomes could cover the 12 formulating processes. The outcomes include the following: 1) Exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers four (4) 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 (8) of the formulating processes.

Lastly, in terms of ***performance indicators in mathematics***, three (3) indicators could capture the 12 formulating processes in PISA: 1) Demonstrate in detail basic mathematical procedures (CMOPOTEPIM3312), which covers three (3) processes; 2) Utilize appropriate technologies to achieve the learning outcomes (CMOPOTEPIM3324), which covers two (2) processes; and 3) Demonstrate skills in various problem-solving heuristics (CMOPOTEPIM3351), which covers seven (7) processes.

Table 1.2

*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	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3311
F2	Identify the key variables in a model	CMOPOG11	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3331
F3	Select a representation appropriate to the problem context	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
F4	Read, decode and make sense of statements, questions, tasks, objects or images to create a model of the situation	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3331
F5	Recognize mathematical structure (including regularities, relationships, and patterns) in problems or situations	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
F6	Identify and describe the mathematical aspects of a real-world problem situation including identifying the significant variables	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
F7	Simplify or decompose a situation or problem in order to make it amenable to mathematical analysis	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
F8	Recognize aspects of a problem that correspond with known problems or mathematical concepts, facts or procedures	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
F9	Translate a problem into a standard mathematical representation or algorithm	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
F10	Use mathematical tools (using appropriate variables, symbols, diagrams) to describe the mathematical structures and/or relationships in a problem	CMOPOG11	CMOPOTE25	CMOPOTEM335	CMOPOTEPIM3324
F11	Apply mathematical tools and computing tool to portray mathematical relationships	CMOPOG11	CMOPOTE25	MOPOTEM331	CMOPOTEPIM3324
F12	Identify the constraints, assumptions simplifications in a mathematical model	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3331

c. *PISA Mathematics Employing Processes*

Table 1.3 shows the 14 **employing processes** that are expected of a mathematically literate 15-year-old learner and how they are covered in the program outcomes and performance indicators of the BSEd Major in Mathematics program (See also Table 1.5 to 1.8). It can be gleaned from the table that there is only one (1) ***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)."

Table 1.3

*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	CMOPOG11	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3312
E2	Select an appropriate strategy from a list	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3351
E3	Implement a given strategy to determine a mathematical solution	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3351
E4	Make mathematical diagrams, graphs, constructions or computing artifacts	CMOPOG11	CMOPOTE25	CMOPOTEM333	CMOPOTEPIM3351
E5	Understand and utilize constructs based on definitions, rules and formal systems including employing familiar algorithms	CMOPOG11	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3312
E6	Develop mathematical diagrams, graphs, constructions or computing artifacts and extracting mathematical information from them	CMOPOG11	CMOPOTE25	CMOPOTEM333	CMOPOTEPIM3351
E7	Manipulate numbers, graphical and statistical data and information, algebraic expressions and equations, and geometric representations	CMOPOG11	CMOPOTE25	MOPOTEM331	CMOPOTEPIM3312
E8	Articulate a solution, showing and/or summarizing and presenting intermediate mathematical results	CMOPOG11	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3312
E9	Use mathematical tools, including technology, simulations and computational thinking, to help find exact or approximate solutions	CMOPOG11	CMOPOTE25	MOPOTEM331	CMOPOTEPIM3324
E10	Make sense of, relate and use a variety of representations when interacting with a problem	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3351
E11	Switch between different representations in the process of finding solutions	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3312
E12	Use a multi-step procedure leading to a mathematical solution, conclusion or generalisation	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3312
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	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
E14	Make generalizations based on the results of applying mathematical procedures to find solutions	CMOPOG11	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3311

In terms of the ***program outcomes in teacher education***, the statement that says that the graduates are expected to "demonstrate mastery of the subject matter/discipline (CMOPOTE22)" could already cover ten (10) employing processes. The other teacher education program outcome that covers four (4) employing processes is "apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25)."

In terms of the BSEd Major in ***Mathematics specific program outcomes***, three (3) outcomes could cover the 14 employing processes: 1) Exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers six (6) of the employing processes; 2) Manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics (CMOPOTEM333), which covers seven (7) of the 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 (1) of the employing processes.

Lastly, in terms of ***performance indicators in mathematics***, three (3) indicators could capture the 14 employing processes in PISA: 1) Demonstrate in detail basic mathematical procedures (CMOPOTEPIM3312), which covers seven (7) processes; 2) Utilize appropriate technologies to achieve the learning outcomes (CMOPOTEPIM3324), which covers one (1) process; and 3) Demonstrate skills in various problem-solving heuristics (CMOPOTEPIM3351), which covers six (6) processes.

d. PISA Mathematics Interpreting Processes

Table 1.4 shows the nine (9) **interpreting processes** that are expected of a mathematically literate 15-year-old learner and how they are covered in the program outcomes and performance indicators of the BSEd Major in Mathematics program (See also Table 1.5 to 1.8). It can be gleaned from the table that there is only one (1) ***general program outcome*** that could already cover the nine (9) 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 statement is broadly stated that could subsume all interpreting processes.

In terms of the ***program outcomes in teacher education***, the statement that says that the graduates are expected to “demonstrate mastery of the subject matter/discipline (CMOPOTE22)” could already cover six (6) interpreting processes. The other teacher education program outcome that covers three (3) interpreting processes is “apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25).”

Table 1.4

*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	CMOPOG11	CMOPOTE22	CMOPOTEM333	CMOPOTEPIM3312
I2	Identify whether a mathematical result or conclusion does, or does not, make sense given the context of a problem	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3332
I3	Identify the limits of the model used to solve a problem	CMOPOG11	CMOPOTE25	CMOPOTEM335	CMOPOTEPIM3351
I4	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	CMOPOG11	CMOPOTE25	CMOPOTEM335	CMOPOTEPIM3324
I5	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	CMOPOG11	CMOPOTE22	CMOPOTEM333	MOPOTEPIM3311
I6	Use knowledge of how the real world impacts the outcomes and calculations of a mathematical procedure or model in order to make contextual judgements about how the results should be adjusted or applied	CMOPOG11	CMOPOTE25	MOPOTEM331	CMOPOTEPIM3312
I7	Construct and communicate explanations and arguments in the context of the problem	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351
I8	Recognize [demonstrate, interpret, explain] the extent and limits of mathematical concepts and mathematical solutions	CMOPOG11	CMOPOTE22	MOPOTEM331	CMOPOTEPIM3311
I9	Understand the relationship between the context of the problem and 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	CMOPOG11	CMOPOTE22	CMOPOTEM335	CMOPOTEPIM3351

In terms of the BSEd Major in Mathematics ***specific program outcomes***, three (3) outcomes could cover the nine (9) interpreting processes: 1) Exhibit competence in mathematical concepts and procedures (CMOPOTEM331), which covers two (2) of the interpreting processes; and 2) Manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics (CMOPOTEM333), which covers two (2) 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 (5) of the interpreting processes.

Lastly, in terms of ***performance indicators in mathematics,*** five (5) indicators could capture the nine (9) interpreting processes in PISA and these include the following: 1) Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed (CMOPOTEPIM3311), which covers two (2) of the interpreting processes; 2) Demonstrate in detail basic mathematical procedures (CMOPOTEPIM3312), which covers two (2) of the interpreting processes; 3) Utilize appropriate technologies to achieve the learning outcomes (CMOPOTEPIM3324), which covers one (1) process; 4) Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving, and critical thinking (CMOPOTEPIM3332), which covers one (1) of the interpreting processes; and 5) Demonstrate skills in various problem solving heuristics (CMOPOTEPIM3351), which covers three (3) of the interpreting processes.

1.1.2 Alignment of the BSEd Major in Mathematics Program Outcomes and Performance Indicators with PISA 2021 Mathematics Core Processes

Table 1.5 to 1.8 show the degree of responsiveness of CMO 75 s. 2017 specifically on how the program outcomes for bachelor's degree, teacher education, and BSEd mathematics and their performance indicators are aligned with the reasoning and problem solving processes emphasized in PISA 2021 Mathematics.

a. General Program Outcomes for a bachelor's degree

Table 1.5 shows the specific program outcomes set in CMO 75 s. 2017 that respond to the reasoning and problem solving processes assessed in PISA 2021 Mathematics.

It can be gleaned from Table 1.5 that two (2) of the five (5) statements of program outcomes in a bachelor's degree (i.e. PQF level 6) could already cover the 53 reasoning and problem solving processes in PISA Mathematics. Almost all (74%) of the PISA mathematics processes are encompassed by the general program outcome requiring graduates to "*articulate and discuss the latest developments in the specific field of practice."* This program outcome demands constant updating of the course syllabi in teacher education programs so that recent developments in mathematics education including those that are influenced by what PISA values in a mathematically literate 15-year-old learner are covered in the pre-service teacher education curriculum. Understanding the developments in education will prepare would-be teachers in solving problems

that they would eventually encounter in their daily life. These same problem solving skills they would have to develop among their future students.

Table 1.5

*Alignment of the **BSEd General Program Outcomes** with the PISA 2021 Mathematics Literacy Core Processes*

CMO No.75. s. 2017 BSEd Program Outcomes	Reasoning Processes	Problem Solving Processes			Total
		Formulating Situations Mathematically	Employing Mathematical Concepts, Facts, Procedures and Reasoning	Interpreting, Applying and Evaluating Mathematical Outcomes	
The graduates have the ability to:					
1. articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11)	R4-R5, R8-R9 Total= 4	F1-12 Total = 12	E1-E14 Total = 14	I1-I9 Total =9	39 (74%)
2. effectively communicate in English and Filipino, both orally and in writing (CMOPOG12)	R1-R3, R6-R7, R10-R18 Total = 14				14 (26%)
Total Processes	**18**	**12**	**14**	**9**	**53 (100%)**

Note. Three (3) out of five (5) BSEd program outcomes not aligned with PISA are no longer shown in the table.

The second program outcome, which states that the graduates are expected to "*effectively communicate in English and Filipino, both orally and in writing,"* also demands that the pre-service teachers should be able to use English and Filipino both orally and in writing in communicating their thoughts particularly in reasoning. PISA Mathematics emphasizes the importance of students' ability to reason or justify how they used mathematical facts, concepts, and procedures in solving problems using English as the language of communication as this is the language of instruction and assessment in most

subjects from Grades 4 to Senior High School in the Philippines. This ability to communicate in English and Filipino that is expected of 15-year old learners must also be developed at a higher level among would-be mathematics teachers.

b. Program Outcomes for Teacher Education Programs

Table 1.6 shows the program outcomes in teacher education set in CMO 75 s. 2017 that respond to the reasoning and problem solving processes assessed in PISA Mathematics.

Table 1.6

*Alignment of the **BSEd Program Outcomes in Teacher Education** with the PISA 2021 Mathematics Literacy Core Processes*

CMO No.75. s. 2017 BSEd Program Outcomes in Teacher Education	**Codes of the PISA Mathematics**				**Total**
	Reasoning Processes	**Problem Solving Processes**			
		Formulating Situations Mathematically	**Employing Mathematical Concepts, Facts, Procedures and Reasoning**	**Interpreting, Applying and Evaluating Mathematical Outcomes**	
The graduates have the ability to:					
1. demonstrate mastery of the subject matter/discipline (CMOPOTE22)	R1 to R18 Total = 18	F1-F9, F12 Total = 10	E1-E3, E5, E8, E10-E14 Total - 10	I1-I2, I5, I7-I9 Total = 6	**44** **(83%)**
2. apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25)		F10-F11 Total = 2	E4, E6-E7, E9 Total = 4	I3-I4, I6 Total = 3	**9** **(17%)**
Total Processes	**18**	**12**	**14**	**9**	**53 (100%)**

Note. Six (6) out of eight (8) BSEd teacher education program outcomes not aligned with PISA are no longer shown in the table.

As shown in Table 1.6, two (2) of the eight (8) statements of program outcomes common in any discipline in teacher education could already cover the 53 reasoning and problem solving processes in PISA Mathematics. Almost

all of the PISA mathematics processes are encompassed by the teacher education program outcome requiring graduates to *"demonstrate mastery of the subject matter/discipline."* This program outcome demands would-be mathematics teachers to learn all the content knowledge covered by the mathematics discipline. In the BSEd program for mathematics majors, there are 63 units of mathematics courses that they need to take for them to master their discipline. These courses cover all the four (4) content domains assessed in PISA Mathematics such as *Space and Shape, Change and Relationship, Uncertainty and Data*, and *Quantity*. Once would-be teachers in mathematics could demonstrate mastery of their subject matter or discipline, then they are capable of demonstrating and developing about 83% of the reasoning and problem solving processes needed among 15-year-old learners.

It is likewise important for would-be mathematics teachers to have the ability to *"apply the skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices"* as stated in its program outcome. This teacher education program outcome will enable the teachers to develop the remaining 17% of the reasoning and problem solving processes in mathematics expected of 15-year-old learners, which involve the use of technologies in mathematics. Moreover, in the BSEd program for mathematics teachers, there is a 3-unit course on *Technology in Teaching and Learning Mathematics (TTL2)*, which could reinforce ICT skills that would-be mathematics teachers are expected to have developed in their more general 3-unit course on *Technology in Teaching and Learning 1.*

c. *Program Outcomes for the Teacher Education Program Major in Mathematics*

Table 1.7 shows the program outcomes in teacher education for mathematics teachers set in CMO 75 s. 2017 that respond to the reasoning and problem solving processes assessed in PISA Mathematics.

As shown in Table 1.7, three (3) of the seven (7) statements of program outcomes in BSE Major in Mathematics could already cover the 53 reasoning and problem solving processes in PISA Mathematics. The program outcome that expects the graduates to have the ability to *"exhibit competence in mathematical concepts and procedures"* covers about 34% of the 53 reasoning and problem solving processes in PISA Mathematics. Another program outcome in the BSE Major in Mathematics where the graduates are expected to have the ability to *"manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics"* covers about 32% of the 53 reasoning and problem solving processes in PISA Mathematics. The remaining

34% of these reasoning and problem solving processes are addressed by the third program outcome targeting that the graduates should be able to *"demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity."* All the other four statements of program outcomes in BSEd mathematics do not explicitly capture the core processes in mathematics literacy defined in PISA. Considering that PISA Mathematics assesses the 15-year-old learners' ability in reasoning and problem solving skills in various contexts from personal to global, this program outcome expects would-be teachers to be prepared in developing the same process skills among their learners in mathematics.

Table 1.7

*Alignment of the **BSEd Program Outcomes for Mathematics Majors** with the PISA 2021 Mathematics Literacy Core Processes*

CMO No.75. s. 2017 BSEd Program Outcomes in Mathematics	**Reasoning Processes**	**Problem Solving Processes**			**Total**
		Formulating Situations Mathematically	**Employing Mathematical Concepts, Facts, Procedures and Reasoning**	**Interpreting, Applying and Evaluating Mathematical Outcomes**	
The graduates have the ability to:					
1. Exhibit competence in mathematical concepts and procedures (CMOPOTEM331)	R1-R3 R5,R7 R9,R11, R18 Total=8	F2, F11 Total = 2	E1,E5,E7-E9, E14 Total= 6	I6, I8 Total = 2	**18 (34%)**
2. Manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics (CMOPOTEM333)	R6,R10, R12,R14 R15, R17 Total = 6	F4, F12 Total = 2	E2-E4, E6, E10-E12 Total = 7	I1, I5 Total = 2	**17 (32%)**
3. Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity (CMOPOTEM335)	R4,R8, R13,R16 Total=4	F1, F3, F5-F10 Total = 8	E13 Total = 1	I2-I4, I7, I9 Total = 5	**18 (34%)**
Total Processes	**18 *(34%)***	**12 *(23%)***	**14 *(26%)***	**9 *(17%)***	**53*(100%)***

Note. Four (4) out of seven (7) BSEd Mathematics program outcomes not aligned with PISA are no longer shown in the table

d. Performance Indicators in the Teacher Education Program Major in Mathematics

Table 1.8 shows the performance indicators in mathematics teacher education set in CMO 75 s. 2017 that could address the reasoning and problem solving processes assessed in PISA Mathematics.

Table 1.8

*Alignment of the **Performance Indicators for BSEd Major in Mathematics** with the PISA 2021 Mathematics Literacy Core Processes*

CMO No.75. s. 2017 BSEd Performance Indicators in Mathematics	Reasoning Processes	Problem Solving Processes			Total
		Formulating Situations Mathematically	Employing Mathematical Concepts, Facts, Procedures and Reasoning	Interpreting, Applying and Evaluating Mathematical Outcomes	
The graduates have the ability to:					
1. Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed (CMOPOTEPIM3311)	R3,R14, R15 Total=3	F8 Total =1	E14 Total =1	I5, I8 Total = 2	**7 (13%)**
2. Demonstrate in detail basic mathematical procedures (CMOPOTEPIM3312)	R5,R7,R9, R11,R18, Total=5		E1,E5,E7-E8, E11-E12 Total = 6	I1, I6 Total = 2	**13 (24%)**
3. Utilize appropriate technologies to achieve the learning outcomes (CMOPOTEPIM3324)		F10, F11 Total = 2	E9 Total =1	I4 Total = 1	**4 (8%)**
4. Demonstrate skills in various methods of learning in mathematics such as conducting investigations, modeling, and doing research (CMOPOTEPIM3331)	R6,R10, R17 Total=3	F2, F4, F12 Total= 3			**6 (11%)**
5. Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking (CMOPOTEPIM3332)	R1-R2, R12 Total =3			I2 Total = 1	**4 (8%)**
6. Demonstrate skills in various problem-solving heuristics (CMOPOTEPIM3351)	R4,R8, R16, R13 Total=4	F1, F3, F5-F7, F9 Total = 8	E2-E4, E6, E10, E13 Total= 6	I3,I7,I9 Total = 3	**19 (36%)**
Total Processes	**18**	**12**	**14**	**9**	**53(100%)**

Note. Eighteen (18) BSEd Mathematics performance indicators not aligned with PISA are no longer shown in the table.

As shown in Table 1.8 six (6) out of 24 performance indicators could capture the 53 reasoning and problem solving processes in PISA. The performance indicator that has the most number of processes covered is *"Demonstrate skills in various problem solving heuristics,"* which covers about 38% of the reasoning and problem solving processes. This is followed by *"Demonstrate in detail basic mathematical procedures,"* which covers about 26% of the reasoning and problem solving processes. The BSEd Mathematics program also emphasizes the need for the graduates to *"Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed"*; *"Demonstrate skills in various methods of learning in mathematics such as conducting investigations, modeling, and doing research"*; "*Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving, and critical thinking"*; and "*Utilize appropriate technologies to achieve the learning outcomes."* It can be deduced from the data that the BSEd Major in Mathematics program covers performance indicators that could respond to the reasoning and problem solving processes expected of the teachers who will likewise develop the same thinking processes among 15-year-old learners.

1.1.3 Alignment of BSEd Major in Mathematics Program with the Content Domains in PISA Mathematics Literacy

The four content categories in PISA 2021 mathematics include a) change and relationships; b) space and shape; c) quantity; and d) uncertainty and data. 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 1.9 shows the specific content under each category. In test development, an item could possibly represent two or more domains. In PISA 2021, some topics under each category will be emphasized as they are viewed not only because they are commonly encountered in adult life but also because they are emerging new areas of the economy (OECD, 2019). These are *Growth Phenomena* (Change and Relationships), *Geometric Approximation* (Space and Shape), *Computer Simulations* (Quantity) and *Conditional Decision Making* (Uncertainty and Data). These content domains in PISA were matched with the content of courses in BSEd Mathematics. The more specific content in PISA as identified by Golla and Reyes (2020) in their analysis of PISA 2021 vis-à-vis Kto12 Curriculum in Mathematics were used as reference in the matching of the PISA content with the BSEd content courses.

Table 1.9

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

Domain Code	PISA 2021 Mathematics Content Domains	PISA Topics Covered (Golla & Reyes, 2020)	BSEd Content Courses in Math (CMO 75 s.2017)
Content 1	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
Content 2	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
Content 3	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
Content 4	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

Space and Shape. In PISA 2021 (OECD, 2018, p. 24), *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. It also requires functions, concepts, measurement, and geometry software together with an emphasis on geometric approximations. In the BSEd Math Curriculum, this content of *Space and Shape* could be learned by the would-be teachers mostly 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 1.9). 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.

Change and Relationships. 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, p24). In the BSEd Math Curriculum, this content could be learned by would-be teachers in specialization courses in Algebra, Geometry, and Statistics. There is no single course where change and relationship could be learned but what is assured is that their needed content are learned in 13 mathematics courses as shown in Table 1.9. 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.

Quantity. In PISA 2021 (OECD, 2018, p25), *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. 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 1.9). These courses should have been designed considering the program outcomes in teacher education 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.

Uncertainty and Data. 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. 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 content for uncertainty and data could be addressed. Since the BSEd program targets 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, this PISA requirement should be addressed.

One can infer from Table 1.9 that each content domain in PISA is covered by 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 prepare them for the expectations of the world of work based on the PISA Mathematics framework. As shown in Table 1.9, 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 way the mathematics courses are designed for would-be teachers in the secondary high school program be interdisciplinary and multi-contextual and multidimensional. Learning of mathematics content should happen as they are applied in different contexts that require their use in solving real-life problems.

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

The PISA Mathematics Literacy Framework underscores the importance of application of mathematics content and cognitive processes in various contexts from ***personal*** (e.g. personal 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 concerns like public transport, government, policies, etc.); and ***scientific*** (i.e. problems related to science and technology like weather, ecology, medicine, etc.) (OECD, 2018).

To understand if the BSE major in Mathematics responds to the requirements of PISA Mathematics Literacy for the 15-year old learners to be able to apply mathematical content knowledge and cognitive processes in different contexts, the mathematics courses in the program were examined in terms of their course description. Twenty-one (21) 3-unit courses were included in this analysis: one general

education in mathematics course and 20 specialization courses. Table 1.10 shows the PISA 2021 mathematics contexts explicitly reflected in the course descriptions of subjects in the BSE Major in Mathematics program.

Table 1.10

*Alignment of the BSE Major in Mathematics Courses with **Context** Requirements of PISA 2021 Mathematics Literacy*

BSE Major in Mathematics Courses		PISA 2021 Mathematics Contexts Domain			
Code	Title	Personal (Context 1)	Occupational (Context 2)	Societal (Context 3)	Scientific (Context 4)
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		✓		
Total	**21**	**2**	**6**	**2**	**6**

Table 1.10 shows that out of 21 courses, the inclusion of learning mathematics in various contexts is made explicit only in 10 courses (about 48%). The General Education course, Mathematics in the Modern World, is the only course that explicitly targets application of mathematics in three of the four contexts such as personal, societal, and scientific. The integration of learning mathematics at the ***occupational*** level is the most common context that is targeted mostly by 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 in phrases indicating scientific investigations (e.g. Problem Solving, Mathematical Investigation & Modeling). However, in PISA test development, when an item is just measuring a mathematical construct without a direct application to an outside context, this item is categorized under scientific context (OECD, 2019, p.30). Thus, courses that mention application of mathematics in real-life contexts were also classified as scientific (e.g. Research in Mathematics). Courses classified to have considered ***personal contexts*** are those that 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 1.10 reveals that among the four contexts in PISA, less emphasis is given to both the *personal* and *societal* applications of mathematics in the BSEd curriculum.

An analysis was also made on the statements of **program outcomes** to find out if they reflect explicitly the need for learning to be applied in various contexts. In the general program outcomes for the bachelor's degree programs, the statements explicitly reflect the value of applying learning at the personal, occupational, societal, and scientific contexts. The same is true in the way the **teacher education program outcomes** have been stated. However, when it comes to the statements of **program outcomes and performance indicators in mathematics**, the explicit targeting of linking mathematics to various contexts is true only to those statements meant for courses focused on pedagogical content knowledge. The most popular contexts targeted is *occupational* followed by s*cientific* 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 gap in how mathematics is taught among would-be teachers. The lack of explicit application of mathematical concepts and procedures in various contexts may lead to poor appreciation of the students of the 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, then they would not be able to perform well given problem solving items. This unfamiliarity with the application of problem solving skills in various contexts could explain students' poor proficiency in mathematics given the PISA examination. 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 the content and delivery of the course, 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 through the course descriptions, the topics, the strategies presented in the syllabi, and the effective implementation of the syllabi itself. Through such modeling, future mathematics teachers will learn the process of integrating problem solving in various contexts. In recent years, many mathematics teachers may 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, 2019).

1.1.5 Alignment of BSEd Major in Mathematics Program with the 21st Century Skills in PISA Mathematics Literacy

The PISA 2021 Mathematics Literacy framework designs assessment by considering not only the thinking processes, content domains, and context domains, but also eight 21st century skills are also believed to be important for 15-year old learners to possess as an indicator of their mathematics literacy. 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).

There are no specific definitions given to these skills but they are identified to have been common in literatures on 21st century skills.

In order to have basis for examining the BSEd Major in Mathematics Program, the 21st century skills in the PISA 2021 Mathematics Framework were operationally defined by the researcher based on the Partnership for the 21st Century Framework and Definitions (P21, 2015). *Critical thinking* is the ability to use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation (P21, 2015) *Creativity* refers to one's ability to think creatively by creating new and worthwhile ideas, by working creatively with others, or by being open to new and diverse ideas (P21, 2015). *Research and Inquiry* refers to gathering and evaluation of information to satisfy one's curiosity, while *Self-direction, initiative, and persistence* refers to how one manages goals and time in doing tasks without direct oversight and one's demonstration of initiative and persistence to advancing one's skills towards a professional level (P21, 2015). Moreover, *Information Use* refers to accurate, creative, and ethical use of information to address the issues or problem at hand (P21, 2015), 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 (P21, 2015). *Communication* refers to one's ability to express thoughts using oral, written, and non-verbal communication skills in a variety of forms, purposes, and contexts (P21, 2015). Finally, *Reflection* refers to one's critical examination of past and present experiences and processes in order to inform future progress (P21, 2015).

Table 1.11 shows the results of the analysis on the evidence of the development of the eight 21st century skills in the design of the BSEd Major in Mathematics program. It can be seen in Table 1.11 that all the eight (8) 21st century skills that are targeted in PISA 2021 Mathematics Framework are addressed in the design of the BSEd Major in Mathematics. At least three (3) statements of program outcomes or performance indicators could address each of the 21st century skills targeted by PISA 2021 Mathematics. It is therefore expected that would-be mathematics teachers would eventually be able to develop the same 21st century skills among their learners.

Table 1.11

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

21st Century Skills in PISA 21 Mathematics Framework	No. of Program Outcomes & Performance Indicators in the BSEd Specifically Addressing the 21st century skills	Example of a Program Outcome*/Performance Indicator** in BSEd Major in Mathematics Program Addressing the 21st Century Skills
Critical Thinking	4	Analyze assessment results and use these to improve learning and teaching**
Creativity	5	Develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners*
Research and Inquiry	3	Demonstrate skills in various methods of learning in mathematics such as, conducting investigations, modeling, and doing research **
Self-direction, initiative, and persistence	5	Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities*
Information Use	8	Apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices*
Systems Thinking	10	Exhibit proficiency in relating mathematics to other curricular areas*
Communication	6	Effectively communicate in English and Filipino, both orally and in writing*
Reflection	3	Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world.*

1.2 Alignment of the BSEd Major in Mathematics Program with PISA Financial Literacy Framework

1.2.1 Alignment of the BSEd Major in Mathematics Program with the Content Domains in PISA Financial Literacy Framework

There are four content domains in PISA financial literacy: money and transactions; planning and managing finances; risk and reward; and financial landscape. Each of these areas are discussed in this section. Table 1.2.1 shows the alignment of the BSEd curriculum in Mathematics with the content domain of PISA Financial Literacy Framework in 2018 specifically on Money and Transactions.

a. Money and Transactions

This content area includes awareness of the different forms and purposes of money and managing monetary transactions, which may include being aware of national, foreign and digital currencies; making payments using a variety of available tools including mobile or online ones, taking into account value for money; and using bank cards, cheques, and bank accounts. It also covers practices such as taking care of cash and other valuables, calculating value for money, and filing documents and receipts, including those received electronically (OECD, 2019). Table 2.1 shows the alignment of the BSEd Major in Mathematics program with the content domain on *Money and Transactions* in PISA Financial Literacy Framework.

General Program Outcomes. *As* shown in Table 2.1, all the content requirements of PISA under *Money and Transactions* could be explicitly covered by two out of the five general program outcomes in the BSEd curriculum. The first is the outcome that states that the graduates are expected to *"articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11).* Although this statement is not explicit in covering money and transactions, it is expected that when teaching the General Education course in Mathematics (GEM) entitled "*Mathematics in the Modern World,"* it should include discussions on the recent developments in financial literacy including money and transactions so that students *"are aware of the different forms and purposes of money,"* considering the course description, to wit:

> **Mathematics in the Modern World** begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission and security and dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and test the students' understanding and capacity. (CHED, 2013, p.6)

In this general education course in mathematics, there is a discussion on managing personal finances which would definitely involve money and transactions.

Table 2.1

Alignment of BSEd Curriculum for Mathematics Major with the Content Domain on Money and Transactions in PISA Financial Literacy Framework in 2021

PISA Financial Literacy Content Domains and Competencies	General Program Outcomes	Teacher Education Program Outcomes	BSEd Math Program Outcomes	BSEd Math Performance Indicators	Math Courses
1. **Are aware of the different forms and purposes of money:**	CMOPOG11	MOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Recognise bank notes and coins;	CMOPOG11	MOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Understand that money can be exchanged for goods and services;	CMOPOG11	MOPOTE23	CMOPOTEM31	CMOPOTEPIM372	GEM, M110
• Understand that money spent on something is not available to be spent on something else;	CMOPOG11	MOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Recognize that money can be stored in various ways, including at home, in a bank, in a post office or in other financial institutions, in cash or electronically;	CMOPOG11	MOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Understand that money held in cash may lose value in real terms over time if there is inflation;	CMOPOG11	MOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Recognize that there are various ways of paying for items purchased, receiving money from other people, and transferring money between people or organizations such as cash, cheques, card payments in person or online, electronic transfers online or via SMS or contactless payments with smartphones, and those new ones continue to be developed;	CMOPOG11	MOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Understand that money can be borrowed or lent, and the purpose of interest (taking into account that the payment and receipt of interest is forbidden in some religions);	CMOPOG11	MOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Are aware that other countries may use different currency from their own, and that exchange rates may change over time; and	CMOPOG11	MOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Are aware of digital currencies.	CMOPOG11	MOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
2. **Are confident and capable at handling and monitoring transactions:**	CMOPOG14	MOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM,
• Can use cash, cards and payment methods through computers and mobile phones to purchase items;	CMOPOG14	CMOPOTE25	CMOPOTEM36	CMOPOTEPIM365	GEM, M110
• Can use cash machines to withdraw cash;	CMOPOG14	CMOPOTE25	CMOPOTEM36	CMOPOTEPIM365	GEM, M110
• Can check an account balance over the internet or through cash machines;	CMOPOG14	CMOPOTE25	CMOPOTEM36	CMOPOTEPIM365	GEM, M110
• Can check receipts after making purchases, and can calculate the correct change if the transaction is made in cash;	CMOPOG14	CMOPOTE28	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Can work out which of two consumer items of different sizes would give better value for money, and understand that this may vary depending on the specific needs and circumstances of the consumer;	CMOPOG14	CMOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Can use common tools, such as paper-and-pen, spreadsheets, online platforms or mobile applications to monitor their transactions and support budget calculations	CMOPOG14	CMOPOTE25	CMOPOTEM36	CMOPOTEPIM365	GEM, M110
• Can check transactions listed on a bank statement provided on paper or digitally and note any irregularities.	CMOPOG14	CMOPOTE25	CMOPOTEM36	CMOPOTEPIM365	GEM, M110

A specialization course in mathematics coded M110 referring to "*Mathematics of Investment"* also covers money and transactions in the way the course description is stated, to wit:

> **Mathematics of Investment** introduces students with a basic understanding of the applications of mathematical concepts and skills in economics, business and accounting. It includes determining the time value of money using simple and compound interest and discounting, variation of annuities, amortization, stocks and bonds, and sinking funds(CHED, 2017, p.53)

This specialization course in mathematics covers applications of mathematical concepts and skills in economics, business, and accounting, which could tackle money and transactions. It may not be explicit that it covers financial literacy, but it is hoped that the tasks under *Money and Transactions* could be discussed.

Another program outcome in BSEd that could represent *Money and Transactions* in PISA is the one that expects the graduates to *"act in recognition of professional, social, and ethical responsibility" (CMOPOG14).* Such a statement that requires acting in recognition of professional, social, and ethical responsibility could be aligned with the need for 15-year old learners to be *"confident and capable at handling and monitoring transactions."* Again, this may not be an explicit alignment but given that courses offered under the BSEd program include at least the two courses (Mathematics in the Modern World and Mathematics of Investment), which involve money and transactions, it is expected that would-be mathematics teachers will be trained in handling and monitoring transactions, which they could eventually teach to their Junior High School (JHS) students.

Teacher Education Program Outcomes. When the BSEd curriculum is further examined based on the teacher education program outcomes, three (3) out of eight (8) stated teacher education program outcomes could implicitly indicate coverage of financial literacy. These teacher education program outcomes are as follows:

- facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23)
- apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25)
- pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)

The teacher education program outcome stated as *"facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23)"* could cover the PISA content that requires 15-year-old learners to be "*aware of the different forms and purposes of money."* All the tasks under the PISA Financial Literacy content are expected to be covered if would-

be teachers are trained to facilitate learning using a wide range of teaching methodologies, including the Integrative Approach in teaching, and if they are taught delivery modes appropriate to specific learners and their environment. They should be exposed to teaching methodologies that would allow them, for example, to recognize banknotes and coins; understand that money can be exchanged for goods and services; understand that money spent on something is not available to be spent on something else; and recognize that money can be stored in various ways, including at home, in a bank, in a post office or in other financial institutions, in cash or electronically. This teaching approach of integrating financial literacy concepts in mathematics courses demands mathematics teachers to have the depth and breadth of knowledge in mathematics and to have strong pedagogical content knowledge.

Another teacher education program outcome stated a*s "apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25)"* covers the PISA content tasks such as*, can use cash, cards and payment methods through computers and mobile phones to purchase items; can use cash machines to withdraw cash; and can check an account balance over the internet or through cash machines*. Since online money transactions have become prevalent in the time of COVID-19, it is expected that these tasks under *Money and Transactions* are embedded in the teaching of mathematics particularly in the two mathematics courses – *Mathematics in the Modern World* and *Mathematics of Investment.*

The last teacher education program outcome that could address the demands of PISA Financial Literacy is *"pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)"*. This statement of teacher education program outcome may cover the PISA content task of *checking receipts after making purchases*, and *calculating the correct change if the transaction is made in cash*. These tasks are common activities in real-life situations; hence, they are expected to be integrated in the BSEd program.

Mathematics Program Outcomes and Performance Indicators. The PISA Financial Literacy content on *Money and Transactions* was also mapped vis-à-vis the program outcomes specific to mathematics and their corresponding performance indicators. As shown in Table 2.1, there are three BSEd mathematics program outcomes with their corresponding performance indicators which could cover *Money and Transactions* in PISA Financial Literacy. Table 2.2 shows the specific program outcome statements in the BSEd curriculum that could cover these contents alongside examples of the content from PISA.

Table 2.2

Program Outcomes and Performance Indicators in the BSEd Mathematics Program that are Responsive to PISA Financial Literacy Content Domain Specific to ***Money and Transactions***

BSEd Major in Mathematics		Example of Tasks under Money and Transaction in PISA Financial Literacy
Program Outcomes in Mathematics	**Performance Indicators in Mathematics**	
Exhibit competence in mathematical concepts and procedures (CMOPOTEM31)	Provide examples to illustrate the application of mathematical concepts and procedures (CMOPOTEPIM314)	*Example 1: Recognize bank notes and coins* *Example 2:* Can check receipts after making purchases, and can calculate the correct change if the transaction is made in cash
Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37)	Develop lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)	*Example 1:* Understand that money can be exchanged for goods and services; *Example 2:* Are aware that other countries may use different currency from their own, and that exchange rates may change over time
Use effectively appropriate approaches, methods, and techniques in teaching mathematics including technological tools (CMOPOTEM36)	Develop and use materials that guide the students in using a mathematical software for discovering and learning mathematical concepts (CMOPOTEPIM365)	*Example 1:* Can use cash, cards and payment methods through computers and mobile phones to purchase items; *Example 2:* Can check an account balance over the internet or through cash machines

As shown in the example on *Money and Transactions* in Table 2.2, there is a need for would-be teachers to exhibit their competence in mathematics concepts and procedures when they *"deal with banknotes and coins"* and when they *"check receipts after making purchases, and calculate the correct change if the transaction is made in cash."* They can provide examples to illustrate the application of mathematical concepts and procedures when making purchases or when calculating change in their financial transactions. In BSEd Math, would-be teachers are expected to *"appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world* (CMOPOTEM37)." They can show such appreciation of mathematics by *"developing lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)."* These lessons in mathematics that they could develop could include, for example, *"understanding that money can be exchanged for goods and services" or* on how they can make their students aware *"that other countries may use different currency from their own, and that exchange rates may change over time."* Lastly, would-be teachers could "*use effectively appropriate approaches, methods, and techniques in teaching mathematics including technological tools (CMOPOTEM36)"* by doing the performance indicator on *"developing and using materials that guide the students in using a mathematical*

software for discovering and learning mathematical concepts (CMOPOTEPIM365).” This outcome and indicator could be realized when would-be teachers *“use cash, cards, and payment methods through computers and mobile phones to purchase items”* or when they *“check an account balance over the internet or through cash machines,”* which are their common experiences in financial transactions especially in the time of COVID-19 when all money transactions are usually done online.

b. Planning and Managing Finances

This content area in PISA 2021 Financial Literacy involves monitoring, managing and planning income, expenditure and wealth both in short and long term to ensure financial well-being. It includes content related to credit use as well as savings and wealth creation (OECD, 2019). Table 2.3 shows the summary of the analysis made on *the Planning and Managing Finances* and how they are mapped with the program outcomes and performance indicators and courses in BSEd Math.

General Program Outcomes. *As* shown in Table 2.3, all the content requirements of PISA under *Planning and Managing Finances* could be explicitly covered by the same two (2) out of the five (5) general program outcomes in the BSEd curriculum discussed under Money and Transactions. These two outcomes include *“articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11) and “act in recognition of professional, social, and ethical responsibility” (CMOPOG14*). These two statements does not explicitly cover *Planning and Managing Finances*. However, the fact that there are two courses (Mathematics in the Modern World and Mathematics of Investment) in the mathematics curriculum that involve finance, it could be assumed that the discussion on the content of the two courses will include recent developments that could affect one’s income, expenditure and, wealth together with the social and ethical responsibility in managing them. For example, would-be teachers should be able to discuss various types of income relevant for young people and for adults (e.g. pocket money, allowances, salary, commission, benefits) in these two courses. As they are groomed to be professional teachers, they should be able to monitor and control income and expenses and make use of their income and other available resources in the short and long terms to enhance financial well-being.

Teacher Education Program Outcomes. *Also* shown in Table 2.3 are program outcomes targeted in teacher education that could address the needed content requirements of PISA under *Planning and Managing Finances*.

Table 2.3

Alignment of BSEd Major in Mathematics Program with the Content Domain on Planning and Managing Finances in PISA 2021 Financial Literacy Framework

Specific Content Under Planning and Managing Finances	General Program Outcomes	Teacher Education Program Outcomes	BSEd Math Program Outcomes	BSEd Math Performance Indicators	Math Courses
1. Knowledge and ability to monitor and control income and expenses:	CMOPOG14	CMOPOTE28	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Identify various types of income relevant for young people and for adults (e.g., pocket money, allowances, salary, commission, benefits),	CMOPOG11	CMOPOTE28	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Be aware that rules for engaging in gainful employment may be different across young people and adults;	CMOPOG14	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand different ways of discussing income (such as hourly wage and gross or net annual income) and that some factors that may affect income (such as different education or career paths);	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Draw up a budget to plan regular spending and saving and stay within it; and	CMOPOG14	CMOPOTE28	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
● Be aware of factors that impact on living standards for any given income, including location, number of dependents and existing commitments.	CMOPOG14	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
2. Knowledge and ability to make use of income and other available resources in the short and long terms to enhance financial well-being:	CMOPOG14	CMOPOTE28	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
● Understand the difference between needs and wants and the idea of living within one's means;	CMOPOG14	CMOPOTE28	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand how to manipulate various elements of a budget, such as thinking about different options for spending money, identifying priorities if income does not meet planned expenses, or finding ways to increase savings, such as reducing expenses or increasing income;	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Assess the impact of different spending plans and be able to set spending priorities in the short and long term, also in the context of external spending pressure;	CMOPOG14	CMOPOTE28	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
● Understand the benefits of a financial plan for future events and plan ahead to pay future expenses: for example, working out how much money needs to be saved each month to make a particular purchase or pay a bill;	CMOPOG11	CMOPOTE28	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand that expenditure can be adjusted over time through borrowing or saving;	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand the reasons why people may use credit, that borrowing money entails a responsibility to repay it, and that the amount to be repaid is usually larger than the amount borrowed due to interest payments (taking into account that the payment and receipt of interest is forbidden in some religions);	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand the idea of building wealth, the impact of compound interest on savings, and the reasons why some people use investment products;	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand the benefits of saving for long term goals or anticipated changes in circumstances (such as living independently);	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand the risks of saving in cash, including the fact that money can be lost, stolen or may lose part of its value in real terms due to inflation; and	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand how government taxes and benefits impact on personal and household finances.	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110

Two program outcomes could cover the content requirements of PISA under *Planning and Managing Finances*: *facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23)* and *pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28).* It is important that as future teachers, the two courses should not only enable the students to gain the knowledge in planning and managing their finances but also train them on how to integrate this knowledge in the teaching of mathematics to high school students. It is also expected that through the two mathematics courses in the BSEd curriculum, would-be teachers would be able to pursue opportunities that could increase their potential income and help them control their expenses for their personal and professional growth.

Mathematics Program Outcomes and Performance Indicators. As shown in Table 2.3 there are two (2) BSEd mathematics program outcomes with their corresponding performance indicators which could cover the content on *Planning and Managing Finances* in PISA Financial Literacy. On the other hand, Table 2.4 shows the specific statements in BSEd curriculum that could cover the sample content areas under *Planning and Managing Finances*. For the program outcome that requires would-be teachers to "*exhibit competence in mathematical concepts and procedures (CMOPOTEM31)"* by doing the performance indicator of "*providing examples to illustrate the application of mathematical concepts and procedures (CMOPOTEPIM314),"* examples of applications of mathematics could focus on planning and management of finances. They could, for example, *"*draw up a budget to plan regular spending and saving and stay within it" or "assess the impact of different spending plans and be able to set spending priorities in the short and long term, also in the context of external spending pressure." Meanwhile, for the second BSEd Mathematics outcome that requires would-be teachers to *"appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37),"* which they could do by *"developing lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372).*" Examples of lessons that they could develop may include those that make students *"aware that rules for engaging in gainful employment may be different across young people and adults."* They could also develop a lesson that would train students on "*how to manipulate various elements of a budget, such as thinking about different options for spending money, identifying priorities if income does not meet planned expenses, or finding ways to increase savings, such as reducing expenses or increasing income."*

Table 2.4

Program Outcomes and Performance Indicators in the BSEd Major in Mathematics that are Responsive to PISA 2021 Financial Literacy Content Domain Specific to ***Planning and Managing Finances***

BSEd Major in Mathematics		Example of Tasks under Planning and Managing Finances in PISA Financial Literacy Framework
Program Outcomes in Mathematics	**Performance Indicators in Mathematics**	
Exhibit competence in mathematical concepts and procedures (CMOPOTEM31)	Provide examples to illustrate the application of mathematical concepts and procedures (CMOPOTEPIM314)	*Example 1:* Draw up a budget to plan regular spending and saving and stay within it *Example 2:* Assess the impact of different spending plans and be able to set spending priorities in the short and long term, also in the context of external spending pressure
Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37)	Develop lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)	*Example 1:* Be aware that rules for engaging in gainful employment may be different across young people and adults; *Example 2:* Understand how to manipulate various elements of a budget, such as thinking about different options for spending money, identifying priorities if income does not meet planned expenses, or finding ways to increase savings, such as reducing expenses or increasing income

c. Risk and Reward

Another content of PISA Financial Literacy, *Risk and Reward* identifies ways of balancing and covering risks and managing finances in uncertainty and understanding of financial gains or losses across a range of financial contexts (OECD, 2019). There are various financial risks including those that an individual could not predict like loss due to catastrophic incidents, which are considered insurable risks. Another risk is a change in circumstances that may have an impact on one's ability to maintain the same standard of living, a risk that is not insurable. The third risk is embedded in financial products like the increase in interest rates or the risk for loss or insufficient returns on investment products. In PISA, what is covered is more on knowledge of risks inherent in certain products and how people could be protected from them through savings and insurance. Table 2.5 shows the summary of the analysis made on the PISA content on *Risk and Reward* and its alignment with the program outcomes, performance indicators, and courses in BSEd Math.

Table 2.5

Alignment of BSEd Major in Mathematics with the Content Domain on Risks and Rewards in PISA 2021 Financial Literacy Framework

Specific Content Under Planning and Managing Finances	General Program Outcomes	Teacher Education Program Outcomes	BSEd Math Program Outcomes	BSEd Math Performance Indicators	Math Courses
1. Identifying those risks that - should the incident occur - are most likely to have a serious negative affect on a particular person, such as:	CMOPOG11	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Accident or injury,	CMOPOG11	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Theft of personal property, passwords or data and digital assets,	CMOPOG11	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Damage or loss of personal property,	CMOPOG11	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Man-made and/or natural catastrophes.	CMOPOG11	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
2. Identifying and managing risks and rewards associated with life events or the economy, such as the potential impact of:	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Job loss, birth or adoption of a child, deteriorating health or mobility;	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Fluctuations in interest rates and exchange rates; and	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Other market changes.	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
3. Recognizing that certain financial products (including insurance) and processes (such as saving) can be used to manage and offset various risks (depending on different needs and circumstances):	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Understand the benefits of saving for unanticipated changes in circumstances; and	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Knowing how to assess whether certain insurance policies may be of benefit, and the level of cover needed.	CMOPOG11	CMOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
4. Understanding the risk inherent in certain credit and investment products, such as risk of capital loss, variability of returns, and the implications of variable interest rates on loan repayments.	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
5. Understanding the benefits of contingency planning and diversification to limit the risk to personal capital.	CMOPOG11	CMOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
6. Applying knowledge of the benefits of contingency planning, diversification and the dangers of default on payment of bills and credit agreements to decisions about:	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Various types of investment, savings and insurance products, where relevant; and	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
• Various forms of credit, including informal and formal credit, unsecured and secured, rotating and fixed term, and those with fixed or variable interest rates.	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
7. Knowing and being cautious about the risks and rewards associated with substitutes for financial products, such as:	CMOPOG14	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Saving in cash or in unregulated digital financial instruments (which may include crypto currencies, depending on national regulation), or buying property, livestock or gold as a store of wealth; and	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
• Taking credit or borrowing money from informal lenders.	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
8. Knowing that there may be unidentified risks and rewards associated with new financial products (such as mobile payment products and online credit).	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110

General Program Outcomes. *As* shown in Table 2.5, all the content requirements of PISA 2021 Financial Literacy under *Risks and Rewards* could be explicitly covered by the same two (2) out of the five (5) general program outcomes in the BSEd curriculum discussed in earlier contents of Financial Literacy. These two outcomes are *"articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11); and "act in recognition of professional, social, and ethical responsibility" (CMOPOG14*). These two statements are not also explicit in covering *Risks and Rewards*. However, the fact that there are two courses (i.e. Mathematics in the Modern World and Mathematics of Investment) in the mathematics curriculum that involve finance, it could be assumed particularly in the course *on Mathematics of Investment* that discussions will include identifying ways of balancing and covering risks, managing finances in uncertainty, and understanding financial gains or losses across a range of financial contexts.

Teacher Education Program Outcomes. Table 2.5 also shows that the same program outcomes that could address the previously cited contents of Financial Literacy could also address the needed content requirements of PISA under *Risks and Rewards*. Two program outcomes could cover them: "*facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment" (CMOPOTE23); and "practice professional and ethical teaching standards sensitive to local, national and global realities" (CMOPOTE27).* It is important particularly in the course on *Mathematics in Investment* to train would-be mathematics teachers to eventually teach students the content knowledge in risks and rewards as they learn mathematics. It is also expected that through the said course, would-be teachers would acquire knowledge of risks inherent in certain products, like when they invest in life insurance or when they save in banks or in lending agencies and know how they could be protected from possible risks.

Mathematics Program Outcomes and Performance Indicators. As shown in Table 2.5, there are two (2) BSEd mathematics program outcomes with their corresponding performance indicators which could cover the content on *Risks and Rewards* in PISA Financial Literacy. Table 2.6 shows the specific statements of program outcomes and performance indicators in the BSEd curriculum that could cover the sample content areas under *Risks and Rewards* in PISA Financial Literacy Framework. The program outcome that requires would-be teachers to *"Exhibit competence in mathematical concepts and procedures (CMOPOTEM31)"* by doing the performance indicator of *"Providing examples to illustrate the application of mathematical concepts and procedures (CMOPOTEPIM314)"* could be made explicit particularly in the course *Mathematics in Investment*. For example, the mathematics lessons could be focused on manage risks and rewards associated with life events or the economy, such as the potential impact of fluctuations in interest rates and exchange rates and other market

changes. They should know how to assess whether a certain insurance policy would be beneficial to them considering its coverage.

Table 2.6

Program Outcomes and Performance Indicators in the BSEd Major in Mathematics Program that are Responsive to PISA Financial Literacy Content Domain Specific to ***Risks and Rewards***

BSEd Major in Mathematics		Example of Tasks under Planning and Managing Finances in PISA Financial Literacy Framework
Program Outcomes in Mathematics	**Performance Indicators in Mathematics**	
Exhibit competence in mathematical concepts and procedures (CMOPOTEM31)	Provide examples to illustrate the application of mathematical concepts and procedures (CMOPOTEPIM314)	*Example 1:* Identifying and managing risks and rewards associated with life events or the economy, such as the potential impact of fluctuations in interest rates and exchange rates and other market changes *Example 2:* Knowing how to assess whether certain insurance policies may be of benefit, and the level of cover needed.
Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37)	Develop lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)	*Example 1:* Understanding the risk inherent in certain credit and investment products, such as risk of capital loss, variability of returns, and the implications of variable interest rates on loan repayments *Example 2:* Knowing and being cautious about the risks and rewards associated with substitutes for financial products, such as taking credit or borrowing money from informal lenders

Another BSEd Mathematics outcome that could cover the content on *Risks and Rewards* in PISA Financial Literacy is the statement *"Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37),"* which they could do by *"Developing lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)."* Consistent with the first two contents of financial literacy, this program outcome and corresponding performance indicator should cover lessons that would enable would-be teachers to appreciate the use of mathematics in understanding the risks inherent in certain credit and investment products, such as risk of capital loss, variability of returns, and the implications of variable interest rates on loan repayments. Lessons should also teach learners how to know risks and how

to be cautious about the risks and rewards associated with substitutes for financial products, such as taking credit or borrowing money from informal lenders. These lessons on risks and rewards could be integrated, for example, in the course Statistics and Probability through contextualized problems on prediction or forecast of investment.

d. Financial Landscape

This content in PISA Financial Literacy 2021 provides an understanding of the features of the existing financial world and how it can change due to a wide variety of factors such as technology, innovation, government policies, and global sustainable growth measures. It also provides an understanding of the consequences of economic policies and conditions such as changes in interest rates, inflation, taxation, sustainability and environmental targets, or welfare benefits for individuals, households, and society (OECD, 2019, p 25). Table 2.7 shows the summary of the analysis made on the PISA content on *Financial Landscape* and its alignment with the program outcomes, performance indicators, and courses in BSEd Math.

General Program Outcomes. As shown in Table 2.7, all the content requirements of PISA under *Financial Landscape* could be implicitly covered by the same two (2) out of the five (5) general program outcomes in the BSEd curriculum discussed in earlier contents of *Financial Literacy*. These two outcomes are *"articulate and discuss the latest developments in the specific field of practice" (PQF level 6 descriptor) (CMOPOG11);* and *"act in recognition of professional, social, and ethical responsibility" (CMOPOG14*). These two statements are not also explicit in covering *Financial Landscape*. However, the fact that there are two courses (i.e. Mathematics in the Modern World and Mathematics of Investment) in the mathematics curriculum that involve finance, it could be assumed that the content of the two courses will include discussion on the landscape of the financial world and how it can change due to a wide variety of factors to include technology, innovation, government policies, and global sustainable growth measures. It should also provide an understanding of the consequences of economic policies and conditions such as changes in interest rates, inflation, taxation, sustainability, and environmental targets, or welfare benefits for individuals, households, and society.

Table 2.7

Alignment of BSEd Major in Mathematics Program to the Content Domain on Financial Landscape in PISA 2021 Financial Literacy Framework

Specific Content Under Financial Landscape	General Program Outcomes	Teacher Education Program Outcomes	BSEd Math Program Outcomes	BSEd Math Performance Indicators	Math Courses
1. Awareness of the role of regulation and consumer protection	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
2. Knowledge of rights and responsibilities, and the ability to apply it to:	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
● Understand that buyers and sellers have rights, such as being able to apply for redress;	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
● Understand that buyers and sellers have responsibilities, such as:	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
⇒ Consumers/investors giving accurate information when applying for financial products;	CMOPOG14	CMOPOTE27	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
⇒ Providers disclosing all material facts; and	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
⇒ Consumers/investors being aware of the implications of one of the parties not doing so.	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Recognize the financial implications of contracts;	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Recognize the importance of the legal documentation provided when purchasing financial products or services and the importance of understanding the content.	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
3. Knowledge and understanding of the financial environment, including:	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understanding that different people and organizations may have incentives to provide certain financial information, products or services;	CMOPOG11	CMOPOTE23	CMOPOTEM31	CMOPOTEPIM314	GEM, M110
● Being able to identify trusted sources of financial information and advice, and to distinguish marketing and ads from genuine and official information and educational messages;	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Being alert to 'fake news' in the financial domain or with financial implications;	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Identifying which providers are trustworthy, and which products and services are protected through regulation or consumer protection laws;	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Identifying whom to ask for advice when choosing financial products, understanding that financial advice may be biased, and knowing where to go for help or guidance in relation to financial matters; and	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
4. Awareness of the financial risks and implications of sharing personal financial data, awareness that personal data may be used to create a person's digital profile which can be used by companies to offer products and services based on personal factors, and awareness of existing financial crimes such as identity theft and data theft;	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
5. Applying an understanding of the financial risks of a lack of data protection to:	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Take appropriate precautions to protect personal data and avoid scams,	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Conduct online transactions safely,	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Know rights and responsibilities under the applicable regulation, including in the event of being a victim.	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
6. Knowledge and understanding of the (short- and long-term) impact of their own financial decisions on themselves, on others, and on the environment:	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand that individuals have choices in spending, saving and investing and each action can have consequences for the individual, for society and possibly for the environment; and	CMOPOG11	CMOPOTE23	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Recognize how personal financial habits, actions and decisions impact at an individual, community, national and international level	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand the financial implications on society of ethics, sustainability and integrity and related behaviors (including for instance donations to non-profits/charities, green investments, corruption).	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
7. Knowledge of the influence of economic and external factors:	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Aware of the economic climate and understand the impact of policy changes such as reforms related to the funding of post-school training or compulsory savings for retirement;	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand how the ability to build wealth or access credit depends on economic factors such as interest rates, inflation and credit scores; and	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110
● Understand that a range of external factors, such as advertising and pressure from family, friends and society, can affect individuals' financial choices and outcomes.	CMOPOG14	CMOPOTE27	CMOPOTEM37	CMOPOTEPIM372	GEM, M110

Teacher Education Program Outcomes. Table 2.7 also shows the program outcomes targeted in teacher education that could address the needed content requirements of PISA under *Financial Landscape*. The two program outcomes that could cover money and transactions, planning and managing finances, risks and rewards, could cover as well the fourth content on financial landscape. They are assumed to be covered in the BSEd Curriculum because of the two courses that explicitly target inclusion of the topic on financial concerns and investment. To *facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23);* and to *practice professional and ethical teaching standards sensitive to local, national, and global realities" (CMOPOTE27)* are powerful program outcome statements in the teacher education program that could imply coverage of the contents of PISA *Financial Literacy* tested among 15-year-old learners. It is important that for future teachers, the two courses should not only enable them to gain knowledge on the financial landscape but also teach them how to integrate this knowledge in the teaching of mathematics to high school students. It is also expected that through the two mathematics courses in the BSEd curriculum would-be teachers would acquire knowledge of their rights and responsibilities as consumers or producers of goods.

Mathematics Program Outcomes and Performance Indicators. Table 2.7 also shows two (2) BSEd mathematics program outcomes with their corresponding performance indicators which could cover all the content on the financial landscape in PISA Financial Literacy. Table 2.8 shows the specific statements in the BSEd curriculum that could cover the sample content areas under the financial landscape. For the program outcome that requires would-be teachers to *"Exhibit competence in mathematical concepts and procedures (CMOPOTEM31),"* the performance indicator is *"Providing examples to illustrate the application of mathematical concepts and procedures (CMOPOTEPIM314)."* One example where such competence in mathematics could be exhibited is by illustrating how one could get incentives when providing certain financial information, products, or services (e.g. incentive in selling a house or lot). Mathematics is also needed by buyers and sellers in their responsibility to give accurate information to their customers/investors who are applying for financial products (e.g. car loans).

The second BSEd Mathematics outcome requires would-be teachers to *"Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37),"* which they could do by *"Developing lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)."* An example lesson that could be developed may focus on explaining that individuals have choices in spending, saving, and investing and each action can have consequences for the individual, for society,

and possibly for the environment. Lessons could also explain how the ability to build wealth or access credit depends on economic factors such as interest rates, inflation, and credit scores.

Table 2.8

Program Outcomes and Performance Indicators *in the BSEd Major in Mathematics Program that are Responsive to PISA 2021 Financial Literacy Content Domain Specific to* ***Financial Landscape***

BSEd Major in Mathematics		Example of Tasks under Financial Landscape in PISA 2021 Financial Literacy Framework
Program Outcomes in Mathematics	**Performance Indicators in Mathematics**	
Exhibit competence in mathematical concepts and procedures (CMOPOTEM31)	Provide examples to illustrate the application of mathematical concepts and procedures (CMOPOTEPIM314)	*Example 1:* Understanding that different people and organizations' may have incentives to provide certain financial information, products or services *Example 2:* Understand that buyers and sellers have responsibilities, such as giving accurate information when applying for financial products
Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37)	Develop lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)	*Example 1:* Understand that individuals have choices in spending, saving and investing and each action can have consequences for the individual, for society and possibly for the environment; and *Example 2:* Understand how the ability to build wealth or access credit depends on economic factors such as interest rates, inflation and credit scores

1.2.2 Alignment of the BSEd Major in Mathematics Program with the Processes in PISA Financial Literacy

There are four processes involved in PISA Financial Literacy. Table 2.9 shows these processes and their alignment with the program outcomes and performance indicators in the BSED mathematics curriculum.

Table 2.9

Alignment of the BSEd Major in Mathematics Program with the Processes in PISA Financial Literacy

PISA Processes	General Program Outcomes	Teacher Education Program Outcomes	BSEd Math Program Outcomes	BSEd Math Performance Indicators	Math Courses
Identify financial information	Articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11)	Facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23)	Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37)	Develop lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)	General Mathematics (GEM)
Analyse financial information and situations					
Evaluate financial issues	Act in recognition of professional, social, and ethical responsibility (CMOPOG14)	Practice professional and ethical teaching standards sensitive to local, national and global realities CMOPOTE27			Mathematics in Investment (M110)
Apply financial knowledge and understanding		Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)			

Identify financial information. In PISA, identifying financial information requires accessing and identifying financial terminologies or information in texts such as contracts, charts, tables, forms, advertisements, and instructions displayed on screen. Examples of tasks in this process include identifying features of a purchase invoice, recognizing the balance on a bank statement, locating information in a contract explaining consequences of defaulting on loan repayments, recognizing terms such as inflation to means increasing prices over time (OECD, 2019). As shown in Table 2.9, this PISA process of identifying information can be addressed by the BSEd program for mathematics considering that there are two mathematics courses that are meant for Financial Literacy. For example, the BSEd program outcome "*Articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11),"* will definitely be a good reminder to the educators handling the course to include information on financial literacy as they discuss the latest developments in "General Education Mathematics (GEM)" and "Mathematics in

Investment" (M110). When they train their students to *"facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23),"* definitely, the students would have to identify the information on financial literacy that they need to deliver through different teaching strategies. Moreover, as BSEd Math also targets would-be teachers' *appreciation of mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37)*, it is inevitable that they would be exposed to different information on financial literacy. Finally, when they are asked *to develop lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)*, it follows that they would have to identify the financial information that they need to apply in daily life.

Analyze financial information and situations. In PISA, this process necessitates seeing the relationship between financial information and contexts that are usually not explicitly stated like recognizing how loan repayments and interest are affected by loan period, or recognizing factors that affect insurance premiums, identifying the underlying assumptions or implications of an issue in a financial context, or comparing the terms offered by different mobile phone providers. Such processes require a wide range of cognitive activities in financial contexts, including interpreting, comparing and contrasting, and synthesizing (OECD, 2019). Again, as there are two courses in mathematics that deal with financial literacy (See Table 2.9), it is assumed that would-be teachers would be trained in *analyzing financial information and situations in these two courses,* in their lesson planning, in designing methods of instruction, or in their discussions of the developments in the field of financial literacy.

Evaluating financial issues. OECD (2019) explains that this process involves construction of justifications and explanations on financial knowledge and understanding as applied in a particular context. Tasks that could be done include explaining the advantages and disadvantages of certain financial decisions or explaining why a certain financial decision is good or bad for someone given their personal situation. It involves cognitive activities such as explaining, reasoning, assessing, and generalizing. For example, a 15-year old learner could be asked of the financial benefit or factors that might be considered when deciding or deferring to purchase something non-essential. As shown in Table 2.9, the process in *evaluating financial issues* will be practiced by would-be teachers in the *Act of recognizing professional, social, and ethical responsibility (CMOPOG14)* as targeted by the BSEd program outcome. When it comes to the teacher education program outcome of Practicing professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27), it is expected that would-be teachers will also be *evaluating financial issues* in their Financial Literacy courses.

Apply financial knowledge and understanding. OECD (2019) explains that this process requires application of knowledge of financial concepts and products in a variety of financial contexts. Tasks given include solving problems and performing simple calculations taking into account multiple conditions. For example, a 15-year old learner could be asked to compute the interest on a loan over two years. As shown in Table 2.9, the PISA process on "*Applying financial knowledge and understanding"* is definitely addressed in the BSEd given its target teacher education program outcome of "*Pursuing lifelong learning for personal and professional growth through varied experiential and field-based opportunities" (CMOPOTE28).* The varied experiential and field-based opportunities will be venues for the application of financial knowledge and understanding gained from the Financial Literacy related courses. Also, the BSEd performance indicator of "*Developing lessons that can help students appreciate the use of mathematics in daily life" (CMOPOTEPIM372)* should be a demonstration of the ability of would-be teachers in planning lessons on how to apply financial knowledge and understanding in the context of the Junior High School students,

It can be seen in Table 2.9 that there is really no explicit match between the PISA Financial literacy processes and any of the general program outcomes, teacher education program outcomes, mathematics program outcomes, and performance indicators. But since there are two courses that will discuss financial aspects in mathematics in the BSEd program, then the teaching of these courses should deliberately target the four PISA financial literacy processes.

The results of the analysis of the alignment of the BSEd Major in Mathematics program with PISA Financial Literacy Framework concurs with the results in the study of Yeban and Florendo (2020) who reported very minimal implicit coverage of the Kto12 curriculum in mathematics of the financial literacy content and processes emphasized in PISA. The lack of emphasis on financial literacy in basic education curriculum could be addressed by mathematics teachers if their foundational knowledge and skills in this literacy is established well while they are being trained in their teacher education program.

1.2.3 Alignment of the BSEd Major in Mathematics Program with the Contexts in PISA 2021 Financial Literacy

There are four contexts involved in PISA Financial Literacy, namely education and work; home and family; individual; and societal context. Table 2.10 shows these contexts and their alignment with the program outcomes and performance indicators in the BSED mathematics curriculum.

Individual. OECD (2019) explained that this context refers to financial decisions involving essential personal needs, leisure, recreation, risks, and responsibilities. This also includes decisions such as opening a bank account, buying shares or getting a loan, securing phone plans, choosing personal products and services, buying consumer goods, and keeping personal information safe and being cautious about unfamiliar products. As shown in Table 2.10, *individual context* is not explicitly reflected in the BSEd general program outcomes, but it can be inferred in the teacher education program outcome on the pursuit of lifelong learning for personal growth and development. However, since there are courses like *General Mathematics* (GEM) and *Mathematics in Investment* (M110) meant to develop financial literacy of 15-year old learners, it can be inferred that the various contexts of financial literacy, including application at the *Individual* context, can also be addressed.

Table 2.10

Alignment of the BSEd Major in Mathematics Program with the ***Contexts*** *in PISA 2021 Financial Literacy*

<table>
<tr><th>PISA Contexts</th><th>General Program Outcomes</th><th>Teacher Education Program Outcomes</th><th>BSEd Math Program Outcomes</th><th>BSEd Math Performance Indicators</th><th>Math Courses</th></tr>
<tr><td>Individual</td><td rowspan="3">Act in recognition of professional, social, and ethical responsibility (CMOPOG14)</td><td rowspan="2">Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)</td><td rowspan="4">Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world (CMOPOTEM37)</td><td rowspan="4">Develop lessons that can help students appreciate the use of mathematics in daily life (CMOPOTEPIM372)</td><td rowspan="4">General Mathematics (GEM)

Mathematics in Investment (M110)</td></tr>
<tr><td>Home and Family</td></tr>
<tr><td>Education and Work</td><td rowspan="2">Practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)</td></tr>
<tr><td>Societal</td></tr>
</table>

Home and Family. OECD (2019) explained that this context refers to issues relating to the costs involved in running a household and decisions about budgeting and prioritizing spending of the family like family events or buying household items. It also includes households that are not based on family relationships such as the shared accommodations that young people often use shortly after leaving the family home. Examples of tasks under this context include buying family groceries, making plans for family events, and budgeting family expenses. As shown in Table 2.10, the PISA

home and family context is not explicitly reflected in the BSEd program outcomes. However, since there are courses like *General Mathematics* (GEM) and *Mathematics in Investment* (M110), it is also expected that financial literacy concepts and services are discussed in different contexts to include *Home and Family* context.

Education and Work. OECD (2019) explained that this educational context is important to 15-year old learners in considering future education options or planning their working life. Work context is also important as there are 15-year old students who start to also engage in paid work outside school hours making work context as important as education context. Tasks that fall under this category include understanding pay slips, planning to save for tertiary education, investigating the benefits and risks in taking out loans, and participating in saving schemes (OECD, 2019). As shown in Table 2.10, the PISA *education and work* context is not explicitly reflected in the BSEd program outcomes and performance indicators. However, it can be implied in the program outcome which trains graduates to *"Act in recognition of professional, social, and ethical responsibility (CMOPOG14)"* that financial literacy should be applied in education and work in the discussion of the courses (*General Mathematics* (GEM) and *Mathematics in Investment* (M110).

Societal Context. OECD (2019) explained that this context includes local community, the nation and global activities like being informed of taxes and consumer rights and responsibilities, understanding the purpose of taxes and local government charges, being aware of business commercial interests, and understanding the financial implications of personal actions on the society, economy and environment at large. This context includes environmental, social and governance considerations with the aim of promoting sustainable economic growth and increasing the awareness of the risks which may have an impact on the sustainability of the financial system. As shown in Table 2.10, the PISA financial literacy social context is explicitly reflected in the general, teacher education, and discipline specific program outcomes and performance indicators in the BSEd Major in Mathematics program. The two courses, *Mathematics in the Modern World* and *Mathematics in Investment* (M110), which hope to develop financial literacy among would-be teachers, will eventually prepare high school learners to apply financial literacy in various contexts including *societal* context.

The analysis of the responsiveness of the BSEd major in mathematics to the four contexts in PISA 2021 financial literacy reveals that there is a minimal alignment of the PISA Financial Literacy contexts with the BSEd Major in Mathematics program. However, to make the curriculum more responsive to the priorities of PISA, the syllabi of the courses in Mathematics that cover Financial Literacy may be reviewed to ensure that the content, processes, and contexts defined in PISA are considered.

1.3 Alignment of the BSEd Major in Mathematics Program with PISA Collaborative Problem Solving Framework

1.3.1 PISA 2015 Collaborative Problem Solving vis-à-vis BSEd Major in Mathematics Program Outcomes and Performance Indicators

a. Collaborative Problem Solving in BSEd Program Outcomes

Table 3.1 shows the results of the analysis made on the BSEd program outcomes as to how responsive they are to the requirements of PISA 2015 Collaborative Problem Solving Framework.

Table 3.1

Alignment of the BSEd Program Outcomes with the PISA 2015 Collaborative Problem Solving Framework

CPS Dimensions	Code	Meaning	BSEd Program Outcomes
Problem Solving Processes (Cognitive Processes)	A	Exploring and understanding	Articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11)
	B	Representing and formulating	Effectively communicate in English and Filipino, both orally and in writing (CMOPOG12)
	C	Planning and executing	Act in recognition of professional, social, and ethical responsibility (CMOPOG14)
	D	Monitoring and reflecting	Preserve and promote "Filipino historical and cultural heritage (based on RA 7722) (CMOPOG15)
Collaborative Processes (Social Processes)	1	Establishing and maintaining shared understanding	Work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13)
	2	Taking appropriate action to solve the problem	Act in recognition of professional, social, and ethical responsibility (CMOPOG14)
	3	Establishing and maintaining team organization	Work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13)
Collaborative Problem-Solving Competencies	A1	Discovering perspectives and abilities of team members	
	B1	Building a shared representation and negotiating the meaning of the problem (common ground)	
	C1	Communicating with team members about the actions to be/being performed	
	D1	Monitoring and repairing the shared understanding	
	A2	Discovering the type of collaborative interaction to solve the problem along with goals	
	B2	Identifying and describing tasks to be completed	Act in recognition of professional, social, and ethical responsibility (CMOPOG14)
	C2	Enacting plans	
	D2	Monitoring results of actions and evaluating success in solving the problem	
	A3	Understanding roles to solve the problem	Work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13)
	B3	Describing roles and team organisation (communication protocols/rules of engagement)	
	C3	Following rules of engagement,(e.g., prompting other team members to perform their tasks)	
	D3	Monitoring, providing feedback and adapting the team organisation and roles	

As shown in the table, four (4) of the BSEd program outcomes could cover the cognitive processes and two for the social processes. All the five (5) BSEd program outcomes were mapped alongside the cognitive and social processes. However, when the cognitive and social processes were combined to form the 12 CPS competencies, only two of the program outcomes could cover them and these are "*Work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13),"* which covers all statements related to the need for shared or collaborative effort and the statement *"Act in recognition of professional, social, and ethical responsibility (CMOPOG14)*" that would require cognitive processes in problem solving.

b. Collaborative Problem Solving in BSEd Teacher Education Program Outcomes

Table 3.2 shows the results of the analysis made on the BSEd teacher education program outcomes as to how responsive they are to the requirements of PISA 2015 Collaborative Problem Solving Framework.

Table 3.2

Alignment of the BSEd Teacher Education Program Outcomes with the PISA 2015 Collaborative Problem Solving Framework

CSP Dimensions	Code	Meaning	BSEd Teacher Education Program Outcomes
Problem Solving Processes (Cognitive Processes)	A	Exploring and understanding	Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)
	B	Representing and formulating	Facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23)
	C	Planning and executing	Develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners (CMOPOTE24)
	D	Monitoring and reflecting	Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)
Collaborative Processes (Social Processes)	1	Establishing and maintaining shared understanding	Practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)
	2	Taking appropriate action to solve the problem	
	3	Establishing and maintaining team organization	
Collaborative Problem-Solving Competencies	A1	Discovering perspectives and abilities of team members	
	B1	Building a shared representation and negotiating the meaning of the problem (common ground)	
	C1	Communicating with team members about the actions to be/being performed	
	D1	Monitoring and repairing the shared understanding	Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)
	A2	Discovering the type of collaborative interaction to solve the problem along with goals	Practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)
	B2	Identifying and describing tasks to be completed	
	C2	Enacting plans	Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)
	D2	Monitoring results of actions and evaluating success in solving the problem	Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)
	A3	Understanding roles to solve the problem	Practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)
	B3	Describing roles and team organisation (communication protocols/rules of engagement)	
	C3	Following rules of engagement,(e.g., prompting other team members to perform their tasks)	
	D3	Monitoring, providing feedback and adapting the team organisation and roles	Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)

As shown in the table, all the problem solving and collaborative processes in PISA CPS could be addressed by the BSEd teacher education program outcomes. The most popular statement of teacher education program outcome is *"Practice professional and ethical teaching standards sensitive to local, national, and global realities (CMOPOTE27)"* as it encompasses the need for would-be teachers to work collaboratively with others since there is a domain on Community Linkages and Professional Engagement in the PPST that demands for such social process.

c. Collaborative Problem Solving in BSEd Major in Mathematics Program Outcomes and Performance Indicators

Table 3.3 shows the results of the analysis made on the BSEd Major in Mathematics program outcomes and performance indicators as to how responsive they are to the requirements of PISA 2015 Collaborative Problem Solving Framework.

As shown in Table 3.3., there is only one (1) out of seven (7) ***program outcomes specific*** to the BSEd major in mathematics that could address one collaborative process and four competencies in PISA CSP. This is to "*Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity.*" However, none of the program outcomes could explicitly cover any of the cognitive processes and eight (8) other competencies.

In terms of the ***performance indicators***, six (6) could capture some of the cognitive processes, social processes, and competencies of CPS: two (2) out of the four (4) cognitive processes, two (2) out of the three (3) social processes, and six (6) out of the 12 competencies of CPS. Two of these performance indicators cover five (5) CPS competencies and these are1) Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving, and critical thinking; and 2) Demonstrate skills in various problem solving heuristics. Both performance indicators focus on problem solving that is why they are aligned with CPS competencies.

Table 3.3

Alignment of the BSEd Major in Mathematics Program Outcomes and Performance Indicators with PISA 2015 Collaborative Problem Solving Framework

CSP Dimensions	Code	Meaning	BSEd Math Program Outcomes	BSEd Math Performance Indicators
Problem Solving Processes (Cognitive Processes)	A	Exploring and understanding		Model in class such mathematical attitudes as delight after having found the solution to a problem or a sense of wonder at how certain mathematical concepts evolved
	B	Representing and formulating		
	C	Planning and executing		Develop lessons that can help students appreciate the use of mathematics in daily life
	D	Monitoring and reflecting		
Collaborative Processes (Social Processes)	1	Establishing and maintaining shared understanding		
	2	Taking appropriate action to solve the problem	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	3	Establishing and maintaining team organization		
Collaborative Problem-Solving Competencies	A1	Discovering perspectives and abilities of team members		
	B1	Building a shared representation and negotiating the meaning of the problem (common ground)	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	C1	Communicating with team members about the actions to be/being performed		
	D1	Monitoring and repairing the shared understanding		
	A2	Discovering the type of collaborative interaction to solve the problem along with goals	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	B2	Identifying and describing tasks to be completed		
	C2	Enacting plans		Develop lessons that can help students appreciate the use of mathematics in daily life
	D2	Monitoring results of actions and evaluating success in solving the problem	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	A3	Understanding roles to solve the problem	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	B3	Describing roles and team organization (communication protocols/rules of engagement)		
	C3	Following rules of engagement,(e.g., prompting other team members to perform their tasks)		
	D3	Monitoring, providing feedback and adapting the team organization and roles		Provide timely feedback of assessment results to students

Table 3.4, shows the summary of the analysis done on the BSEd and the PISA CPS Framework. It can be gleaned from Table 3.4 that all the individual and collaborative problem solving processes emphasized in PISA 2012 and 2015 have an implicit match with some of the general program outcomes, teacher education program outcomes, mathematics specific program outcomes, and performance indicators in the BSEd Major in Mathematics program. Most PISA CPS processes that have an implicit match in the BSEd program are those that mention "collaboration or team" problem solving processes. Once the process requires "collaboration," it is difficult to find an explicit match in the BSEd curriculum as there is only one among all statements of program outcomes and performance indicators that explicitly gives value to collaboration. This statement is a general PQF level 6 performance indicator stating that the graduates are expected to *"Work effectively and **collaboratively** with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF*

Table 3.4

Alignment of the BSEd General Teacher Education and Mathematics-Specific Program Outcomes and Performance Indicators with PISA 2015 Collaborative Problem Solving Framework

CSP Dimensions	Code	Meaning	BSEd Program Outcomes	BSEd Teacher Education Program Outcomes	BSEd Math Program Outcomes	BSEd Math Performance Indicators
Problem Solving Processes (Cognitive Processes)	A	Exploring and understanding	Articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11)	Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)		Model in class such mathematical attitudes as delight after having found the solution to a problem or a sense of wonder at how certain mathematical concepts evolved
	B	Representing and formulating	Effectively communicate in English and Filipino, both orally and in writing (CMOPOG12)	Facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23)		
	C	Planning and executing	Act in recognition of professional, social, and ethical responsibility (CMOPOG14)	Develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners (CMOPOTE24)		Develop lessons that can help students appreciate the use of mathematics in daily life
	D	Monitoring and reflecting	Preserve and promote "Filipino historical and cultural heritage (based on RA 7722) (CMOPOG15)	Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)		
Collaborative Processes (Social Processes)	1	Establishing and maintaining shared understanding	Work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13)	Practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)		
	2	Taking appropriate action to solve the problem	Act in recognition of professional, social, and ethical responsibility (CMOPOG14)		Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	3	Establishing and maintaining team organization	Work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13)			
Collaborative Problem-Solving Competencies	A1	Discovering perspectives and abilities of team members				
	B1	Building a shared representation and negotiating the meaning of the problem (common ground)			Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	C1	Communicating with team members about the actions to be/being performed				
	D1	Monitoring and repairing the shared understanding		Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)		
	A2	Discovering the type of collaborative interaction to solve the problem along with goals		Practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	B2	Identifying and describing tasks to be completed	Act in recognition of professional, social, and ethical responsibility (CMOPOG14)			
	C2	Enacting plans		Pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)		Develop lessons that can help students appreciate the use of mathematics in daily life
	D2	Monitoring results of actions and evaluating success in solving the problem		Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	A3	Understanding roles to solve the problem	Work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13)	Practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking Demonstrate skills in various problem-solving heuristics
	B3	Describing roles and team organization (communication protocols/rules of engagement)				
	C3	Following rules of engagement,(e.g., prompting other team members to perform their tasks)				
	D3	Monitoring, providing feedback and adapting the team organization and roles		Demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)		Provide timely feedback of assessment results to students

level 6 descriptor). Likewise, when the CPS process mentions problem solving, there is a corresponding match in the mathematics program outcomes and performance indicators since mathematics provides a perfect training ground for the development of students' problem solving skills.

Given the results, it can be concluded that collaboration is an explicit target of any program in PQF level 6, but it is not explicitly targeting collaborative problem solving. On the other hand, problem solving is an explicit target of the BSEd Mathematics curriculum, but it does not specifically target collaboration. As BSEd Mathematics is under PQF Level 6, it may be concluded that it is implicitly aligned with the intentions of collaborative problem solving that PISA 2015 emphasizes.

1.2.2 PISA 2015 Collaborative Problem Solving vis-à-vis BSEd Mathematics Courses

Further analysis was done in the BSEd Mathematics curriculum through examination of the courses and their descriptions. Table 3.5 shows the courses in the BSEd Major in Mathematics Curriculum and their responsiveness to the demands on collaborative problem solving in Mathematics.

As shown in Table 3.5, seven (7) or 1/3 of the 21 courses do not capture either explicitly or implicitly any of the collaborative problem solving skills in the way the courses were described. Following are examples of how these courses are described in CMO 75 s. 2017 indicative of some intentions to address collaborative problem solving.

Example 1: Elementary Statistics and Probability

> The course equips the students with the basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS. (CHED, 2017, p.)

The given course description for ***Elementary Statistics and Probability*** integrates two collaborative problem solving skills. The first skill is on "*Understanding roles to solve the problem (A3)"* as implied in the phrase "…allow the students to be able to perform hypothesis testing on real-life problems from different fields." This statement, however, is more on addressing the individual problem solving skill of *"Exploring and Understanding (A)"* but not so explicit about the collaborative skill of "*Establishing and maintaining team organization (3)."* Another skill embedded in this course description is *"enacting plans (C2)."* This skill could be implied in the phrase "The course includes applications and data analysis with computations carried out

using SPSS." The course description captures the individual problem solving skill again of "*Planning and Executing (C)"* and the collaborative skill of "*Taking appropriate action to solve the problem (2)."*

In another example of a short course description (i.e. Calculus 3), the same collaborative problem solving skills could be implied.

Example 2: Calculus 3

The course aims to provide the students with an understanding of the applications of differentiation and integration in sequences, infinite series, power series, as well as of multiple integration for functions in several variables. Moreover, students will be able to apply these concepts to problem solving. (CHED, 2017, p.53.)

Table 3.5

BSEd Math Courses vis-a-vis the PISA 2015 Collaborative Problem Solving Skills

Code	Course Titles in BSEd Major in Mathematics	PISA 2015 Collaborative Problem Solving Skills
GEM	Mathematics in the Modern World	
M100	History of Math	
M101	College and Advanced Algebra	
M102	Trigonometry	A3
M103	Plane and Solid Geometry	
M104	Logic and Set Theory	
M105	Elementary Statistics and Probability	A3, C2
M106	Calculus 1 with Analytic Geometry	B2
M107	Calculus 2	
M108	Calculus 3	A3, C2
M109	Modern Geometry	
M110	Mathematics of Investment	B2
M111	Number Theory	B2, D2
M112	Linear Algebra	C2
M113	Advanced Statistics	C2
M114	Problem Solving, Mathematical Investigation & Modeling	A3, C2, D2
M115	Principles and Strategies in Teaching Mathematics	C2
M116	Abstract Algebra	D2
M117	Research in Mathematics	C2
M118	Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics)	C2, D2
M119	Assessment and Evaluation in Mathematics	D2
Total	**21**	**14**

The given course description for ***Calculus 3*** *also* integrates the same two collaborative problem solving skills. The first skill is on "*Understanding roles to solve the problem (A3)"* as implied in the phrase "…students will be able to apply these concepts to problem solving." This statement is more on addressing the individual problem solving skill of *"Exploring and Understanding (A),"* but it is not so explicit about the collaborative skill of "*Establishing and maintaining team organization (3)."* Another skill embedded in this course description is *"enacting plans (C2)."* This skill could be implied in the phrase *"provide the students with an understanding of the applications of differentiation and integration in sequences …."* The course description captures the individual problem solving skill of *"Planning and Executing (C)"* and the collaborative skill of *"Taking appropriate action to solve the problem (2)."*

Based on the two course descriptions, it can be inferred that there has been the intention of addressing the individual problem solving skills. However, the course descriptions were not so explicit about the collaborative skills needed to be developed among would-be teachers. These two courses are not problem solving courses, but the courses could be a venue for the students to acquire knowledge and skills in solving real-life problems. Interestingly, there is a course (i.e. Problem Solving, Mathematical Investigation & Modeling) in mathematics under the BSEd program that is specific to problem solving as shown below.

Example 3: Problem Solving, Mathematical Investigation & Modeling

> The course deepens and further enhances the students' understanding of real life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations. (CHED, 2017,p.54)

Three collaborative problem solving skills are implicitly integrated in the course description of the course ***Problem Solving, Mathematical Investigation & Modeling*** and these are (A3) Understanding roles to solve the problem; (C2) Enacting plans; and (D2) Monitoring results of actions and evaluating success in solving the problem. The phrase "…enhances the students' understanding of real-life applications of mathematics" could address A3 and C2, while "…pattern finding, testing and justifying conjectures, and making generalizations" could indicate D2.

Again, all these three sample course descriptions seem to be focused more on the individual problem solving, which was emphasized in PISA 2012. However, they do not focus much on collaborative problem solving that is also highlighted in PISA 2015. Nevertheless, because one of the program outcomes for PQF level 6 where this bachelor's degree in education (i.e. BSEd) falls states that "*The graduates are expected to work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor)"*

(CHED, 2017, p.3), it is hoped that the design of all courses would explicitly enable the pre-service teachers to work individually and collaboratively in teams including tasks that would require problem solving skills.

In other courses, however, one could not infer the intentions of the course in developing either individual or collaborative problems solving skills set in PISA. In the course on College and Advance Algebra, the course description states:

Example 4: **College and Advanced Algebra**

> The course builds upon the students' knowledge on properties of the real number system, operations on the different types of algebraic expressions, and the solution of various types of equations and inequalities. The course also covers the prerequisites to trigonometry and calculus, specifically transcendental and non-transcendental functions, including the characteristics of their graphs and applications. (CHED, 2017, p.51)

One could infer that the course is heavy on developing students' content knowledge. There is no clear indication as to the thinking skills that are also targeted and more specifically the collaborative problem solving skills that are valued in PISA 2015. Another course (i.e. Plane and Solid Geometry) shows the same emphasis on acquisition of pedagogical content knowledge as shown in the following course description

Example 5: Plane and Solid Geometry

> The course covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates, and theorems on plane and solid geometry. (CHED, 2017, p. 52)

As illustrated by Examples 3 and 4, there are courses prescribed in the BSEd curriculum for Mathematics majors that highlight knowledge acquisition. The course descriptions for the two sample mathematics courses focus only on the content knowledge that the students have to acquire from the course. They do not explain the thinking skills required for the students to acquire the content knowledge including how such content knowledge could help build the students' ability to perform collaborative problem solving skills.

It can be concluded that the BSEd Major in Mathematics program targets individual problem solving skills,, but it does not explicitly develop students' collaborative problem solving skills. This result is consistent with the findings of David and Reyes (2020) who likewise analyzed the alignment of the Kto12 mathematics curriculum with the collaborative problem solving skills emphasized in PISA 2015. Their study pointed out that only about 17% of the competencies in mathematics for

Grades 7 to 10 could implicitly capture collaborative problem solving skills. Most of those competencies explicitly discussed problem solving skills but not necessarily collaboratively done.

The foregoing analysis tells the need for course descriptions to include not only the content knowledge or pedagogical content knowledge that would-be mathematics teachers must acquire, but also the thinking and collaborative skills that they need to develop as they acquire this knowledge. The program outcome for any bachelor's degree that requires the graduates "to work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor)" (CHED, 2017) should be a good reminder to all course developers to be consistent in the way they design their courses for them to be aligned with target program outcomes and to capture international benchmarks like those set in PISA or other ILSAs where collaborative problem solving is of value. Thus, as teachers design courses and prepare their course syllabi, they must remember that the actual learning activities and assessment should develop not only the problem solving skills of students, but also their collaborative skills as well.

1.4 Alignment of the BSEd Major in Mathematics Program with PISA 2021 Creative Thinking

1.4.1 Alignment of the BSEd General Program Outcomes with the Content Domains and Competencies of PISA 2021 Creative Thinking

a. PISA 2021 Creative Thinking Content Domains in BSEd Program Outcomes

Table 4.1 shows the four creative thinking domains emphasized in PISA 2021: written and visual creative expressions; and social and scientific problem solving.

As shown in the table, three (3) of the four (4) content domains of creative thinking are covered in the way the BSEd program outcomes are stated. For the ***written creative expression***, this domain could be covered in the program outcome *"effectively communicate in English and Filipino, both orally and in writing."* The word "writing" in the program outcome statement could be a venue for developing students' creative expressions in writing. For the ***visual creative expression***, none from the five (5) program statements explicitly mentions the development of this domain of creative thinking. For ***creative scientific problem solving***, this could be captured when realizing the program outcome "articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor)." The phrase "latest developments" could be seen as a venue for the creation of scientific solutions to problems

using the latest developments in the field of mathematics education. For ***creative social problem solving***, there are three (3) program outcomes that could target its development among would-be mathematics teachers: 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). The keywords that were underscored in the statements like the words "collaborative," "multicultural teams," "social," and "cultural" all point to possibilities for the development of would-be mathematics teachers' creativity in finding solutions to social problems.

Table 4.1

Alignment of the BSEd General Program Outcomes with PISA 2021 Creative Thinking Content Domains and Competencies

General Program Outcomes of BSEd	Generate Diverse Ideas				Generate Creative Ideas				Evaluate and Improve Ideas				Total
	W	V	Sc	So	W	V	Sc	So	W	V	Sc	S	
The graduates have the ability to:													
1. articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor)											/		1
2. effectively communicate in English and Filipino, both orally and in writing	/												1
3. work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor)												/	1
4. act in recognition of professional, social, and ethical responsibility												/	1
5. preserve and promote "Filipino historical and cultural heritage (based on RA 7722)												/	1
Total	**1**										**1**	**3**	**5**

Legend: W-written; V-visual; Sc- scientific; and So-Social

b. PISA 2021 Creative Thinking Competencies in BSEd Program Outcomes

Table 4.1 also shows the three creative thinking competencies emphasized in PISA 2021: generate diverse ideas; generate creative Ideas; and evaluate and improve ideas.

It can be gleaned from the table that the creative thinking competency of ***"generating diverse ideas"*** could be addressed by the program statement "effectively communicate in English and Filipino, both orally and in writing". The requirement to effectively express one's ideas in English and Filipino both in oral and written form could encourage generation of diverse ideas. However, there is no program outcome statement where one could infer the chance for the development of the competency ***"generating creative ideas."*** Nevertheless, there are four program outcomes where one could assume that the competency of ***"evaluating and improving ideas"*** could be developed by would-be mathematics teachers. These outcomes include "articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor)"; "work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor); "act in recognition of professional, social, and ethical responsibility"; and "preserve and promote the Filipino historical and cultural heritage (based on RA 7722)."

1.4.2 Alignment of the BSEd Teacher Education Program Outcome with the Content Domains and Competencies of PISA 2021 Creative Thinking

a. PISA 2021 Creative Thinking Content Domains in BSEd Teacher Education Program Outcomes

Table 4.2 shows the results of the analysis of the responsiveness of the BSEd teacher education program outcomes in terms of meeting the content domains and competencies of PISA 2021 creative thinking. It can be gleaned from the table that all the four (4) content domains of PISA 2021 creative thinking could be covered by the BSEd teacher education program outcomes.

As shown in the table, the ***written creative expression*** could be covered in the teacher education program outcome "facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment." The phrase "wide range of teaching methodologies and delivery modes" in the program outcome statement could be made more explicit by emphasizing the development of students' creative expressions through a variety of teaching methodologies and delivery modes.

Table 4.2

Alignment of the BSEd Teacher Education Program Outcomes with PISA 2021 Creative Thinking Content Domains and Competencies

BSEd Teacher Education Program Outcomes	Generate Diverse Ideas				Generate Creative Ideas				Evaluate and Improve Ideas				Total
	W	V	Sc	So	W	V	Sc	So	W	V	Sc	So	
The graduates have the ability to:													
1. articulate the rootedness of education in philosophical, socio-cultural, historical, psychological, and political contexts												/	**1**
2. demonstrate mastery of the subject matter/discipline													**0**
3. facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment	/												**1**
4. develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners						/							**1**
5. apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices											/		**1**
6. demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes			/										**1**
7. practice professional and ethical teaching standards sensitive to local, national and global realities												/	**1**
8. pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities				/									**1**
Total	**1**	**0**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**7**

Legend: W-written; V-visual; Sc- scientific; and So-Social

For the ***visual creative expression***, the development of this domain of creative thinking could happen when instruction targets the program statement "develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners." The innovative resources that could be produced to realize this teacher education program outcome could be in visual form for them to be more appealing to the diverse types of learners who will benefit from their use.

For ***creative scientific problem solving***, this could be captured when realizing the teacher education program outcome "apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices." The phrase "development and utilization of ICT" could be an opportunity for the creation of scientific solutions to problems using the latest developments in the field of mathematics education.

For ***creative social problem solving***, the teacher education program outcome "practice professional and ethical teaching standards sensitive to local, national, and global realities," could be a venue for its development. The keywords that were underscored in the statements like the words "local, national, and global realities" entail the need for would-be mathematics teachers' creativity in finding solutions to social problems.

b. *PISA 2021 Creative Thinking Competencies in BSEd Teacher Education Program Outcomes*

Table 4.2 also shows the creative thinking competencies covered by the BSEd teacher education program outcomes.

As shown in the table, the competency on ***"generating diverse ideas"*** could be addressed by the program statement "demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes." The word "variety" connotes diversity, hence, this target would also enable the generation of diverse ideas in planning, monitoring, assessing, and reporting learning processes and outcomes.

The competency ***"generating creative ideas"*** could be attained by the teacher education program outcome "develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners". This outcome expects would-be mathematics teachers to develop innovative curriculum, instructional plans, teaching approaches, and resources, which could also be a venue for the generation of creative ideas.

The competency of ***"evaluating and improving ideas"*** could be developed by would-be mathematics teachers when they "articulate the rootedness of education in philosophical, socio-cultural, historical, psychological, and political contexts." In this program outcome, it is expected that would-be mathematics teachers would be able to evaluate the foundations of education and identify their strengths and weaknesses as basis for proposing better educational practices in different contexts.

1.4.3 Alignment of the BSEd Mathematics Program Outcomes and Performance Indicators with the PISA 2021 Creative Thinking Content Domains and Competencies

a. PISA 2021 Creative Thinking Domains in BSEd Major in Mathematics

Table 4.3 shows the results of the analysis on the responsiveness of the BSEd major in mathematics program outcomes and performance indicators in terms of meeting the content domains and competencies of PISA 2021 creative thinking. It should be noted that the mapping of the program outcomes and performance indicators in the BSEd program vis-à-vis the PISA creative thinking content domains and competencies is guided by how PISA defines creative thinking. This definition of creative thinking refers to generation of new or diverse ideas. It does not include application of ideas. Hence, program outcomes and performance indicators that begin with verb like "use", "utilize" and even "demonstrate" where not considered as they may just demand for application of knowledge and skills and may not necessarily require generation of new, diverse or improved ideas.

It can be gleaned from Table 4.3 that only three (3) of the seven (7) program outcomes and only 16 of the 24 performance indicators of BSEd Math may address the domains and competencies of creative thinking in PISA 2021. The domain ***written creative expression*** has no clear alignment with any of the seven (7) program outcomes of BSEd major in mathematics. However, there are three (3) performance indicators that could capture it. The performance indicators "*Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed"* and *"Provide examples to illustrate the application of mathematical concepts and procedures"* may demand for written creative expressions when one illustrates mathematical concepts. The performance indicator "*Create a curriculum guide that shows how mathematics can be integrated with other curricular areas"* could require a curriculum guide that is expressed in written form. Hence, written creative expression of PISA creative thinking is expected to be attained as well. For the ***visual creative expression***, the two performance indicators in the BSEd math program requiring illustration of mathematical concepts or procedures may invite

visual illustrations, which means that they could be a venue as well for the development of visual creative expressions.

For ***creative scientific problem solving***, three (3) of the seven (7) BSEd math program outcomes could attain this domain: 1) *Demonstrate competence in designing, constructing, and utilizing different forms of assessment in mathematics; 2) Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity; and 3) Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world.* These statements explicitly emphasize the need for creativity where outputs could be considered evidence of scientific problem solving.

As shown in Table 4.3, 11 of the 23 performance indicators are expected to develop students' creativity in scientifically solving problems. Example of a performance indicator in mathematics that promotes scientific problem solving is *"Develop and utilize instructional materials that support the integration of mathematics with other curricular areas."* As mathematics teachers are usually just focused on the teaching of mathematics, developing instructional materials that show integration of mathematics with other curricular areas would be new to them and would open various opportunities for creatively presenting outputs, which could be considered as evidence of creativity.

With regard to ***creative social problem solving***, none from the BSEd math program outcomes and performance indicators could explicitly develop this domain of creativity.

b. *PISA 2021 Creative Thinking Competencies in BSEd Major in Mathematics Program Outcomes and Performance Indicators*

As shown in Table 4.3, there is no clear program outcome specific to BSEd Major in Mathematics that could develop the competency on ***"generating diverse ideas."*** However, three (3) performance indicators could address this. The performance indicator "*Demonstrate knowledge and skills in varied approaches and methods of teaching mathematics"* could address this competency. The phrase "varied approaches" may connote generation of diverse ideas in teaching mathematics. The performance indicators "*Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed"* and *"Provide examples to illustrate the application of mathematical concepts and procedures."* These two performance indicators that require illustrations may lead to generation of diverse ideas that could be expressed written or visual form.

Table 4.3

*Alignment of the **BSEd Mathematics Program Outcomes** and **Performance Indicators** with the PISA 2021 Creative Thinking Content Domains and Competencies*

BSEd Mathematics Program Outcomes & Performance Indicators	Generate Diverse Ideas				Generate Creative Ideas				Evaluate and Improve Ideas				Total
	W	V	Sc	So	W	V	Sc	So	W	V	Sc	S	
The graduates have the ability to:													
1. Exhibit competence in mathematical concepts and procedures													**0**
⇒ Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed	■	■											**1**
⇒ Demonstrate in detail basic mathematical procedures													**0**
⇒ Show the connections between mathematical concepts that are related to one another													**0**
⇒ Provide examples to illustrate the application of mathematical concepts and procedures	■	■											**1**
2. Exhibit proficiency in relating mathematics to other curricular areas													**0**
⇒ Create a curriculum guide that shows how mathematics can be integrated with other curricular areas					■								**1**
⇒ Identify teaching activities which support the implementation of the curriculum guide													**0**
⇒ Develop and utilize instructional materials that support the integration of mathematics with other curricular areas							■						**1**
⇒ Utilize appropriate technologies to achieve the learning outcomes													**0**
3. Manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics													**0**
⇒ Demonstrate skills in various methods of learning in mathematics such as, conducting investigations, modeling, and doing research							■						**1**
⇒ Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking							■						**1**
4. Demonstrate competence in designing, constructing, and utilizing different forms of assessment in mathematics							■						**1**
⇒ Design and utilize varied assessment tools in mathematics, including alternative forms of assessment							■						**1**
⇒ Analyze assessment results and use these to improve learning and teaching											■		**1**
⇒ Provide timely feedback of assessment results to students													**0**
5. Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity							■						**1**
⇒ Demonstrate skills in various problem solving heuristics													**0**
⇒ Select suitable examples to explain the various problem-solving heuristics													**0**
⇒ Manifest creativity and critical thinking when selecting examples and problems to be used in the classroom and in the assessment of students learning											■		**1**
⇒ Use varied resources for selecting and creating problems to develop the students' problem-solving skills							■						**1**
6. Use effectively appropriate approaches, methods, and techniques in teaching mathematics including technological tools													**0**
⇒ Demonstrate knowledge and skills in varied approaches and methods of teaching mathematics			■										**1**
⇒ Manifest discretion when selecting approaches or methods that would be effective in teaching particular lessons													**0**
⇒ Utilize a variety of student-centered approaches and methods in the classroom													**0**
⇒ Demonstrate skills in the use of common mathematical software for teaching and learning mathematical concepts, e.g., Graphmatica, GeoGebra and Geometer's Sketchpad													**0**
⇒ Develop and use materials that guide the students in using a mathematical software for discovering and learning mathematical concepts							■						**1**
7. Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world.							■						**1**
⇒ Model in class such mathematical attitudes as delight after having found the solution to a problem or a sense of wonder at how certain mathematical concepts evolved							■						**1**
⇒ Develop lessons that can help students appreciate the use of mathematics in daily life							■						**1**
Total (Program Outcomes in BSEd Mathematics)	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**3**
Total (Performance Indicator in BSEd Mathematics)	**2**	**2**	**1**	**0**	**1**	**0**	**8**	**0**	**0**	**0**	**2**	**0**	**16**

Legend: W-written; V-visual; Sc- scientific; and So-social

For the competency ***"generating creative ideas,"*** two (2) BSEd math program outcomes could attain this: 1) Demonstrate competence in designing, constructing, and utilizing different forms of assessment in mathematics; and 2) Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery, and gaining insights of the world. There are also nine (9) performance indicators that could be a venue for the development of this competency on creative thinking. These include 1) Create a curriculum guide that shows how mathematics can be integrated with other curricular areas; 2) Develop and utilize instructional materials that support the integration of mathematics with other curricular areas; 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; 5) Design and utilize varied assessment tools in mathematics, including alternative forms of assessment; 6) Use varied resources for selecting and creating problems to develop the students' problem solving skills; 7) Develop and use materials that guide the students in using a mathematical software for discovering and learning mathematical concepts; 8) Model in class such mathematical attitudes as delight after having found the solution to a problem or a sense of wonder at how certain mathematical concepts evolved; and 9) Develop lessons that can help students appreciate the use of mathematics in daily life.

For the competency of ***"evaluating and improving ideas,"*** none of the program outcomes in BSEd Major in Mathematics could explicitly develop this competency. However, there are two performance indicators where this competency could be covered: 1) Analyze assessment results and use these to improve learning and teaching; and 2) Manifest creativity and critical thinking when selecting examples and problems to be used in the classroom and in the assessment of students' learning.

1.4.4 Alignment of the BSEd Major in Mathematics Courses with the PISA 2021 Creative Thinking Content Domains and Competencies

a. ***PISA 2021 Creative Thinking Domains in the Course of BSEd Major in Mathematics***

Table 4.4 shows the results of the analysis on the responsiveness of the mathematics courses in the BSEd Major in Mathematics program in terms of meeting the content domains of PISA 2021 creative thinking. Only ten (10) or about 48% of the courses in the program could be a venue for the development of would-be mathematics teachers' creative thinking in the different domains

and facets or competencies of learning. The other 11 courses in the program that were not mapped under creative thinking are described as venues for the acquisition of knowledge, understanding, and skills applied in mathematics, which is not what creative thinking demands. Creative thinking demands for evaluation and generation of new or diverse ideas to improve learning and practice.

Table 4.4

*Alignment of the **BSEd Mathematics Courses** with the PISA 2021 Creative Thinking Content Domains and Competencies*

PISA Creative Thinking Competencies	PISA Content Domains				Total
	Creative Expression		Knowledge Creation and Problem Solving		
	Written	Visual	Scientific	Social	
Generate Diverse Ideas	0	1	3	1*	**4** *(19%)*
Generate Creative Ideas	1	1	2	0	**4** *(19%)*
Evaluate and Improve Ideas	0	0	2	0	**2** *(10%)*
Total Mathematics Courses Aligned	**1**	**2**	**7**	**1***	**10** *(48%)*
Total No. of Mathematics Courses in BSEd Program					**21(***100%)*

* This number was not anymore added as it is already counted in another domain.

Table 4.4 shows three (3) courses in the BSEd Major in Mathematics program where ***creative expression*** could be developed. These are the courses on *Plane and Geometry* (M103); *Mathematics in the Modern World* (General Education Mathematics); and Abstract Algebra (M116).

For ***Written Expression,*** as shown in Table 4.4, one mathematics course can develop among would-be mathematics teachers their ability to create ideas expressed in written form. This course is on *Plane and Solid Geometry* (M103) with the following description:

> This course on Plane and Solid Geometry covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry. (CMO, 75, s.2017, p.52)
>
> .

The given course description emphasizes making conjectures of definitions, corollaries, postulates and theorems, which could invite creative expressions in written form. Another course in Mathematics is

OECD (2019) explained that written expression domain is a natural means of creative expression both outside and inside the school context. Creative writing is a way of asking readers to believe in one's imagination. It could be fiction or nonfiction. Fiction could include writing stories that are based on fantasy. Non-fiction, on the other hand, could include writing slogans and taglines. In cognitive tests on creativity, written expressions could engage students in an open and imaginative writing, generate ideas for various stimuli, or make an original improvement of someone else's written work. Creative writing can help students understand and master basic rules of effective communication.

*For **Visual Expression,*** Table 4.4 shows two mathematics courses explicitly target the development of would-be mathematics teachers' ability to create ideas expressed in visual form. The first course is the General Education Mathematics (GEM) titled "*Mathematics in the Modern World,"* which has the following course description:

> Mathematics in the Modern World is a course that begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission, and security and dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and test the students' understanding and capacity. (CMO, 20, s.2013, p.6)

Given the course description of *Mathematics in the Modern World*, one can infer that the course expects would-be mathematics teachers to express creative ideas in visual form when they show results of their "exploration of patterns." The pre-service teachers are also expected to show "appreciation of geometric designs," which could happen when they create these designs in visual form.

Another mathematics course that trains students on visual expression is the course *Abstract Algebra* (M116), which has the following the course description:

> Abstract Algebra is a study of basic algebraic structures such as groups, rings, integral domains and fields. It provides a basic understanding of relations focusing on isomorphism. It aims to enhance the student's skills in constructing

> mathematical proofs, and develop their symbolic thinking and appreciation of mathematical structures. (CMO, 75, s.2017, p.54)

Based on the course description of *Abstract Algebra*, it aims "to enhance students' skills in constructing mathematical proofs, and develop their symbolic thinking and appreciation of mathematical structures." Such a description indicates that ideas created could be expressed visually using mathematical symbols or figures.

OECD (2019), explained that in *Visual Expression Domain*, students need to explore, experiment, and communicate their ideas and own experiences using a range of media, materials, and processes (Irish National Teacher Association, 2009, cited in OECD, 2019). This kind of creative thinking could help students to interpret both overt and subtle images and to develop a better understanding of how information, communication, and design work in general. In a cognitive test on creative thinking specifically on visual expression, students are asked to engage in open visual design tasks using a digital drawing tool; generate visual design ideas based on a scenario and stimuli provided in the unit; and suggest or make original improvements to different forms of visual expression, following given instructions or additional information.

The other content domain of creative thinking is *knowledge creation and creative problem solving*, which is divided into scientific problem solving and social problem solving. For this domain, seven (7) courses in mathematics target creative thinking. These courses, however, tend to just cover scientific but not social problem solving. The courses that focus on scientific problem solving include Elementary Statistics and Probability (M105); Calculus 1 with Analytic Geometry (M106); Number Theory (M111); Problem Solving, Mathematical Investigation & Modeling (M114); Research in Mathematics (M117); Technology in Teaching and Learning (TTL) 2 (M118); and Assessment and Evaluation in Mathematics (M119).

For ***Social Problem Solving,*** as shown in Table 4.4, one course in mathematics explicitly describes the intention of developing would-be teachers' creativity in finding unique solutions to societal or global problems. This is the course *"Mathematics in the Modern World"* which is a General Education course in mathematics. Its course description explicitly articulates the need to address social problems:

> Mathematics in the Modern World is a course that begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission, and security and

> dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and test the students' understanding and capacity. (CMO, 20, s.2013, p.6)

The emphasis on "dealing with various aspects of present-day living such as managing personal finances and making social choices" relates to the intention of developing would-be mathematics teachers' capability to create solutions to social problems. As OECD (2019) explained, creative problem solving requires understanding and addressing the needs of others by finding solutions to central problems be them at personal, school, or a wider community or global level. Creative thinking in this domain depends on the students' ability to empathize with and evaluate the needs of a specific group, recognize patterns, and construct ideas that have emotional meaning, as well as propose innovative yet functional solutions (Brown & Wyatt, 2010 cited in OECD, 2019). In a cognitive test on creative social problem solving, the students are asked to engage in open problem solving tasks with a social focus, either individually or in simulated collaborative scenarios. The examinees generate ideas for solutions to social problems based on a given scenario and suggest original improvements to problem solutions.

For ***Scientific Problem Solving***, as shown in Table 4.4, seven (7) mathematics courses in the BSEd Major in Mathematics program can be considered as avenues for the development of creative scientific problem solving skills based on their course description. The first mathematics course that could serve as a venue for would-be teachers to demonstrate their ability to create and not just to apply knowledge to solve scientific problems is *Elementary Statistics and Probability* (M105) with the course description as follows:

> The course Elementary Statistics and Probability equips the students with the basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS. (CMO, 75, s.2017, p.52)

The course description explicitly indicates testing of hypotheses in real-life problems in different fields. The performance of these tests of hypotheses is considered a form of creative scientific problem solving. Another course is *Calculus 1 with Analytic Geometry* (M106) as shown in the following course description:

> The course Calculus 1 with Analytic Geometry equips the students with knowledge and skills needed to be able to determine limits of functions to differentiate and to integrate algebraic, exponential, logarithmic, and

> trigonometric functions in one variable. It also includes exposures to more challenging problems covering continuity and areas of regions. (CMO, 75, s.2017, p.52)

This course description does not explicitly state the creation of scientific solutions to problems, but it could be inferred that since they have exposure to more challenging problems covering continuity and areas of regions, then there is a chance for would-be mathematics teachers to develop their ability to create scientific solutions to problems.

The course on *Number Theory* (M111) also provides opportunity for the creation of scientific solutions to problems given course description below:

> The course Number Theory is a study of the properties of numbers and their proofs. It presents the students with different methods of mathematical proving. It focuses on the discussion of the set of integers that include Unique Prime Factorization, Divisibility Rules, Euclidean Algorithm, Linear Congruences and Linear Diophantine Equations. (CMO, 75, s.2017, p.52)

Since this course on *Number Theory* involves proving, which means that would-be mathematics teachers will have to create different ways on how to solve problems. Solutions could go beyond just the application of previously known solutions to problems. The course *Problem Solving, Mathematical Investigation & Modeling* (M114), is another venue for the development of creative scientific problem solving as shown in the following course description:

> The course deepens and further enhances the students' understanding of real life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.(CMO, 75, s.2017, p.52)

Another course in mathematics in the BSEd program is *Research in Mathematics* (M117), which is also a good venue for the development of would-be mathematics teachers‘ creative thinking. The following course description proves this.

> The course **Research in Mathematics** aims to prepare prospective mathematics teachers to undertake an undergraduate research project. It gives teachers the opportunity to conduct researches that address problems, issues, and concerns in mathematics teaching and learning. It also showcases their research skills through the application of the mathematical content and processes they have learned previously.” (CMO, 75, s.2017, p.54)

Similarly, the course *Technology in Teaching and Learning (TTL) 2* (M118), could also target the development of creative thinking given the following course description:

> **TTL2** is a 3-unit course which will focus on the application , design, production, utilization, and evaluation of information and Communications Technology (ICT) materials for teaching and learning in Mathematics Education Programs. The major requirement for this course is an ICT-integrated and Project-based Learning Plan aligned to the K to12 curriculum. All the learning activities and course requirements will revolve around the student-teacher developed Learning Plan." (CMO, 75, s.2017, p.52)

The last course in the BSEd Major in Mathematics program where one could infer the development of creative scientific problem solving is the course on *Assessment and Evaluation in Mathematics* (M119), which has the following course description:

> The course **Assessment and Evaluation in Mathematics** deals with traditional and authentic assessment methods for evaluating mathematics learning. It covers the purposes of instruction and assessment, the relationship of assessment to content and performance standards, and discussions on the issues and trends in assessment specifically in mathematics teaching." (CMO, 75, s.2017, p.52)

In this domain of creative thinking, new ideas are conceived to advance scientific knowledge, to probe hypotheses, to develop scientific ideas or inventions applied to particular domains of practical interest; or to implement novel plans and blueprints for scientific/engineering activities (OECD, 2019). Creative thinking in science is closely related to scientific inquiry skills. It focuses on generation of ideas rather than application of taught knowledge and on originality of students' creative thinking processes in scientific contexts.

b. ***PISA 2021 Creative Thinking Competencies in the Courses of BSEd Major in Mathematics***

Table 4.4 also shows five (5) or about 24% of the courses in BSEd Major in Mathematics where the competency on ***generating diverse ideas*** could be developed. These are the courses on *Mathematics in the Modern World* (a General Education Mathematics); *Plane and Solid Geometry* (M103); *Elementary Statistics and Probability* (M105); *Calculus 1 with Analytic Geometry* (M106); and *Number Theory* (M111). The following are their course descriptions where one could infer the emphasis on generating diverse ideas (See Table 4.5).

Table 4.5

*BSEd Mathematics Courses that address the competency on **Generating Diverse Ideas** in PISA 2021 Creative Thinking Framework*

Course Code	Course Title	Course Description (Based from CMO 74 s.2017)
GEM	Mathematics in the Modern World	The course begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission and security and dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and test the students' understanding and capacity.
M103	Plane and Solid Geometry	The course covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry.
M105	Elementary Statistics and Probability	The course equips the students with the basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS.
M106	Calculus 1 with Analytic Geometry	The course equips the students with knowledge and skills needed to be able to determine limits of functions to differentiate and to integrate algebraic, exponential, logarithmic, and trigonometric functions in one variable. It also includes exposures to more challenging problems covering continuity and areas of regions.
M111	Number Theory	The course is a study of the properties of numbers and their proofs. It presents the students with different methods of mathematical proving. It focuses on the discussion of the set of integers that include Unique Prime Factorization, Divisibility Rules, Euclidean Algorithm, Linear Congruences and Linear Diophantine Equations.

As shown in Table 4.5, the parts in the course descriptions that explicitly inform the emphasis on generating diverse ideas are underscored. For example, in

Mathematics in the Modern World, one has to deal with "various aspects of present day living." In *Plane and Solid Geometry*, "both the deductive and inductive methods" are needed. In *Elementary Statistics and Probability*, understanding " various phenomena" and hypothesis testing on real-life problems from " different fields" are emphasized. Moreover, in *Calculus 1 with Analytic Geometry*, there is an emphasis on integrating "algebraic, exponential, logarithmic, and trigonometric functions and exposures" to "more challenging problems." Finally, in *Number Theory*, there is an emphasis on the need to generate "different methods of mathematical proving." As OECD (2019) has explained, the competency on *generating diverse ideas* falls under creative thinking if it invites diversity of ideas or non-adherence to common ideas.

For **generating creative Ideas,** as shown in Table 4.6, there are three (3) or about 14% of the courses in BSEd mathematics where the competency of generating creative ideas could be developed. These are the courses on *Abstract Algebra* (M116); *Research in Mathematics* (M117); *Technology in Teaching and Learning* (TTL) **2** (M118); and *Assessment and Evaluation in Mathematics* (M119). The following are their course descriptions where one could infer the emphasis on generating creative ideas (See Table 4.6).

As shown in Table 4.6, the parts in the course descriptions that explicitly state the emphasis on *generating creative ideas* are underscored. For example, in *Abstract Algebra*, emphasis is given to "constructing mathematical proofs," which is an act of creating innovative ideas. Meanwhile, in the course on *Research in Mathematics*, students are expected to "conduct various research that address problems, issues, and concerns in mathematics teaching and learning." Since research leads to knowledge creation, then this quoted phrase indicates the need to generate creative ideas. Lastly, in the course on *Technology for Teaching and Learning 2* (Instrumentation and Technology in Mathematics), there is an emphasis on "design and production" and "ICT-integrated and Project-based Learning Plan," which invites creativity when would-be mathematics teachers "develop a Learning Plan." As OECD (2019) has explained, the competency *generating creative ideas* falls under creative thinking if it invites creation of new or innovative ideas or solutions to a problem.

Table 4.6

*BSEd Mathematics Courses that address the competency on **Generating Creative Ideas** in PISA 2021 Creative Thinking Framework*

Course Code	Course Title	Course Description (Based from CMO 74 s.2017)
M116	Abstract Algebra	The course is a study of basic algebraic structures such as groups, rings, integral domains and fields. It provides a basic understanding of relations focusing on isomorphism. It aims to enhance the student's skills in constructing mathematical proofs and develop their symbolic thinking and appreciation of mathematical structures.
M117	Research in Mathematics	The course aims to prepare prospective mathematics teachers to undertake an undergraduate research project. It gives teachers the opportunity to conduct research that address problems, issues, and concerns in mathematics teaching and learning. It also showcases their research skills through the application of the mathematical content and processes they have learned previously.
M118	Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics)	TTL2 is a 3-unit course which will focus on the application, design, production, utilization, and evaluation of information and Communications Technology (ICT) materials for teaching and learning in Mathematics Education Programs. The major requirement for this course is an ICT-integrated and Project-based Learning Plan aligned to the K to12 curriculum. All the learning activities and course requirements will revolve around the student-teacher developed Learning Plan.

Table 4.7 shows that two (2) or about 10% of the courses in BSEd mathematics could cover the competency on **evaluating and improving ideas**. These are the courses on *Abstract Algebra* (M116); *Research in Mathematics* (M117); *Technology in Teaching and Learning* (TTL) 2 (M118); and *Assessment and Evaluation in*

Mathematics (M119). The following are their course descriptions where one could infer the emphasis on generating creative ideas (See Table 4.7).

Table 4.7

*BSEd Mathematics Courses that address the competency on **Evaluating and Improving Ideas** in PISA 2021 Creative Thinking Framework*

Course Code	Course Title	Course Description (Based from CMO 74 s.2017)
M114	Problem Solving, Mathematical Investigation & Modeling	The course deepens and further enhances the students' understanding of real-life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.
M119	Assessment and Evaluation in Mathematics	The course deals with traditional and authentic assessment methods for evaluating mathematics learning. It covers the purposes of instruction and assessment, the relationship of assessment to content and performance standards, and discussions on the issues and trends in assessment specifically in mathematics teaching.

As shown in Table 4.7, the parts in the course descriptions that explicitly state the emphasis on *evaluating and improving ideas* are underscored. For example, in *Problem Solving, Mathematical Investigation & Modeling,* emphasis is given to "investigating, pattern finding, testing and justifying conjectures, and making generalizations," which are competencies that would require evaluation to improve an idea. Similarly, the course *Assessment and Evaluation in Mathematics* also *underscores the need to "*evaluate mathematics learning" by seeing the "relationship of assessment to content and performance standards." This focus on evaluation leads to improving students' learning in mathematics as informed by the evaluation of assessment results. As OECD (2019) has explained, ***e**valuating and improving ideas* refers to one's capacity to identify limitations and find original ways to improve them or an act in providing feedback on the strengths and weaknesses of others' ideas to improve the creative outcome (i.e. reshaping an innovative idea).

The analysis of the BSEd Major in Mathematics program outcomes, performance indicators, and courses as to how responsive they are in addressing the challenges of PISA 2021 Creative Thinking Framework reveals that creative thinking is developed among would-be mathematics teachers. However, its integration in the

teacher preparation program is minimal as only 10 or about 48% of the mathematics courses emphasize some content domains and competencies of PISA creative thinking. The results of this analysis on financial literacy in the mathematics teacher preparation concur with what Rungduin and Papango (2020) did as they analyzed as well the alignment of English Language and Arts in the Kto12 program to PISA creative thinking. Rungduin and Papango reported that there is integration of the development of creative thinking in these two courses in the Kto12 program but creativity focuses more on generating creative ideas but not much on generating diverse ideas or on evaluating and improving ideas. They further explained that the two courses in the Kto12 curriculum focuses more on creative expression but minimal on knowledge creation and problem solving, which are also indicators of creativity in the PISA creative thinking framework.

2. Proposed Improvements in the BSEd Major in Mathematics Program to Address Gaps based on the PISA Frameworks

2.1 Gaps in BSEd Major in Mathematics Program

Table 5 shows the gaps in the current program offering of BSEd Major in Mathematics.

Table 5

Summary of Gaps in BSEd Mathematics Program based on PISA Assessment Frameworks and Recommended Actions

Components of the BSEd Major in Mathematics	Mathematics Literacy	Financial Literacy	Collaborative Problem Solving	Creative Thinking	Recommended Improvement
General Program Outcomes	none	Lacks explicit coverage of individual and home or family contexts valued in PISA financial literacy framework	none	Not captured visual creative expression and generation of creative ideas	Restate some general outcomes to accommodate creative expressions in written and visual form and generation of creative ideas
Teacher Education Program Outcomes	none	none	none	None	none
BSEd Mathematics Program Outcomes	none	none	No explicit statement mentioning the specific problem solving and social processes that are emphasized in CPS.	No explicit statement targeting written and visual creative expressions and creative social problem solving as well as the competencies on generating diverse ideas and in evaluating and improving ideas	Restate BSEd Major in Mathematics program outcomes to explicitly cover the specific cognitive and social processes in PISA 2015 CPS and the creative domains and competencies in PISA 2021 Creative Thinking Framework.
BSEd Mathematics Performance Indicators	none	none	No explicit statement mentioning the collaborative problem-solving processes that are emphasized in CPS.	No explicit statement targeting creative social problem solving	Restate some of the 24 performance indicators in BSEd Mathematics to accommodate the need to develop social problem-solving processes as well as the creative social problem solving emphasized in PISA CPS and Creative Thinking Frameworks
BSEd Mathematics Courses	Only 10 out 21 courses have clear contexts (personal, occupational, societal and global) for learning of mathematics	Only two of the 21 courses could explicitly cover financial literacy contents and contexts.	Only 14 out of 21 courses could implicitly cover the competencies for collaborative problem solving.	Only 10 out of 21 courses integrate development of creative thinking.	Review course descriptions to explicitly reflect the need to develop financial literacy, collaborative problem solving, creative thinking as the highest cognitive skill to be targeted by the course in different contexts from personal to scientific contexts.

As shown in Table 5, the identified gaps are more on the following areas: a) *BSEd Program Outcomes* - non-explicit coverage of the individual and home contexts of PISA 2021 financial literacy as well as the creative expression domain and the competence on generating creative ideas in PISA 2021 Creative Thinking Framework; b) *BSEd Major in Mathematics program outcomes* **-** non-explicit coverage of the specific cognitive and social processes in PISA 2015 CPS and the creative domains and competencies in PISA 2021 Creative Thinking Framework; c) *BSEd Major in Mathematics Performance Indicators* - non-explicit development of CPS processes and the domains and competencies of PISA Creative Thinking Frameworks; and d) *BSEd Major in Mathematics Course Descriptions* **-** limited and non-explicit targeting of the context of Mathematics literacy, financial literacy, as well as the content and competencies in CPS and Creative Thinking in PISA.

2.1 Proposed Improvements in the BSEd Major in Mathematics Program

Considering the identified gaps, the following are the recommended improvements in the BSEd Major in Mathematics program to address the challenges posed by the PISA mathematics literacy framework..

a. BSEd Program Outcomes

Table 5.1 shows the proposed improvements in the statement of program outcomes in the BSEd to address the identified gaps based on PISA Frameworks.

Table 5.1

*Recommended Revisions in the BSEd **Program Outcomes** to Address Identified Gaps based on PISA Frameworks*

General Program Outcomes of BSEd Mathematics	Proposed Improvements based on PISA Framework	Justification
The graduates have the ability to:		
1. articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor) (CMOPOG11)	none	none
2. effectively communicate in English and Filipino, both orally and in writing (CMOPOG12)	effectively communicate in English and Filipino, in oral, written, or visual form	To accommodate the visual creative expression in PISA Creative Thinking Framework
3. work effectively and collaboratively with substantial degree of	none	none

independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor) (CMOPOG13)		
4. act in recognition of professional, social, and ethical responsibility (CMOPOG14)	act in recognition of personal, professional, social, and ethical responsibilities	To accommodate the need to be a responsible individual, and to include the home and family financial needs emphasized in PISA Financial Literacy Framework
5. preserve and promote Filipino historical and cultural heritage (based on RA 7722) (CMOPOG15)	none	none

b. BSEd Teacher Education Program Outcomes

Table 5.2 shows the proposed improvements in the statement of teacher education program outcomes in the BSEd program to address the identified gaps based on PISA Frameworks.

Table 5.2

Recommended Revisions in the Teacher Education Program Outcomes in BSEd Major in Mathematics

BSEd Teacher Education Program Outcomes	Proposed Improvements based on PISA Framework	Justification
The graduates have the ability to:		
1. articulate the rootedness of education in philosophical, socio-cultural, historical, psychological, and political contexts (CMOPOTE21)	none	none
2. demonstrate mastery of the subject matter/discipline (CMOPOTE22)	none	none
3. facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment (CMOPOTE23)	none	none

4. develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners (CMOPOTE24)	none	none
5. apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices (CMOPOTE25)	apply problem solving and creative thinking skills in the development, utilization, evaluation and improvement of ICT to promote quality, relevant, and sustainable educational practices	To explicitly cover the PISA CPS and creative thinking competencies
6. demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes (CMOPOTE26)	demonstrate a variety of thinking skills including reasoning, problem solving and creative thinking in planning, monitoring, assessing, and reporting learning processes and outcomes	To explicitly cover the PISA mathematics processes of reasoning, problem solving, and creative thinking
7. practice professional and ethical teaching standards sensitive to local, national and global realities (CMOPOTE27)	practice professional and ethical teaching standards sensitive to personal, local, national and global realities	To explicitly include personal and not only local, national, and global realities as contexts where teaching could take place to meet the context domain of PISA mathematics and financial literacy framework
8. pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities (CMOPOTE28)	pursue lifelong learning for personal and professional growth and societal progress through varied experiential and field-based opportunities	To explicitly include societal context emphasized in financial literacy.

c. BSEd Teacher Education Program Outcomes

Table 5.3 shows the proposed improvements in the statement of program outcomes in the BSEd Major in Mathematics program to address the identified gaps based on PISA Frameworks.

Table 5.3

Recommended Revisions in the Program Outcomes and Performance Indicators in BSEd Major in Mathematics

BSEd Mathematics Program Outcomes & Performance Indicators	Proposed Improvements based on PISA Framework	Justification
The graduates have the ability to:		
1. Exhibit competence in mathematical concepts and procedures	Exhibit competence in mathematical and financial concepts, skills and processes applied in different contexts	To accommodate the processes and skills in PISA Mathematics and Financial Literacy Framework
⇒ Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed	Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts and processes using relevant examples applied in different contexts	To emphasize the need for the development of mathematics concepts and processes applied in different contexts defined in PISA Mathematics Literacy Framework
⇒ Demonstrate in detail basic mathematical procedures	Demonstrate in detail basic mathematical procedures and processes applied in various contexts	To make it explicit the mathematics processes applied in different contexts defined in PISA Mathematics Literacy Framework
⇒ Show the connections between mathematical concepts that are related to one another	none	none
⇒ Provide examples to illustrate the application of mathematical concepts and procedures	Apply mathematical and financial concepts and procedures in different contexts (e.g., personal, occupational,	To emphasize the applications of mathematics and financial literacy in different contexts as emphasized in PISA Mathematics

	societal, scientific, global)	and Financial Literacy Framework
2. Exhibit proficiency in relating mathematics to other curricular areas	Exhibit proficiency and creativity in relating mathematics to finance and other curricular areas	To emphasize the need to develop mathematics and financial literacy as well as creative thinking among would-be mathematics teachers
⇒ Create a curriculum guide that shows how mathematics can be integrated with other curricular areas	none	none
⇒ Identify teaching activities which support the implementation of the curriculum guide	none	none
⇒ Develop and utilize instructional materials that support the integration of mathematics with other curricular areas	none	none
⇒ Utilize appropriate technologies to achieve the learning outcomes	none	none
3. Manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics	none	none
⇒ Demonstrate skills in various methods of learning in mathematics such as, conducting investigations, modeling, and doing research	none	none
⇒ Create and utilize learning experiences in the classroom which develop the learners' skills in discovery learning, problem solving and critical thinking	none	none

4. Demonstrate competence in designing, constructing, and utilizing different forms of assessment in mathematics	Demonstrate competence and creativity in designing, constructing, utilizing, evaluating and improving multidimensional, multimodal and varied assessment tools in mathematics	To emphasize the need to develop creative thinking and to familiarize would-be teachers not only to paper-based but also computer-based multidimensional assessments of students' learning similar to PISA
⇒ Design and utilize varied assessment tools in mathematics, including alternative forms of assessment	Design and utilize multidimensional, multimodal and varied assessment tools in mathematics, including alternative forms of assessment	To have a performance indicator consistent with the program outcome that accommodates the need for multidimensional and computer-based assessment in mathematics similar to PISA assessment framework
⇒ Analyze assessment results and use these to improve learning and teaching	none	none
⇒ Provide timely feedback of assessment results to students	none	none
5. Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity	Demonstrate proficiency in individual and collaborative problem solving by solving and creating routine and non-routine problems in different contexts and levels of complexity	To emphasize the need to develop not only individual but also collaborative problem-solving skills applied in different contexts among would-be mathematics teachers as emphasized in PISA

⇒ Demonstrate skills in various problem-solving heuristics	Demonstrate skills in various problem-solving heuristics including individual, collaborative, scientific, and social problem-solving techniques	To emphasize creative ways of solving problems using scientific and social approaches emphasized in PISA Creative Thinking Framework and Collaborative Problem Solving
⇒ Select suitable examples to explain the various problem-solving heuristics	none	none
⇒ Manifest creativity and critical thinking when selecting examples and problems to be used in the classroom and in the assessment of students learning	Manifest creativity and critical thinking when selecting, evaluating and improving examples and problems to be used in the classroom and in the assessment of students learning	To promote the competencies of creative thinking as defined in PISA Creative Thinking Framework
⇒ Use varied resources for selecting and creating problems to develop the students' problem-solving skills	Use varied and innovative resources for selecting and creating problems to develop the students' individual and collaborative problem-solving skills in different contexts	To make it explicit the need to develop creative thinking and individual as well as collaborative problem-solving skills applied in different contexts among would-be mathematics teachers as emphasized in PISA
6. Use effectively appropriate approaches, methods, and techniques in teaching mathematics including technological tools	Use effectively appropriate approaches, methods, and techniques in teaching mathematical and financial concepts and processes with ICT integration	To promote teaching of mathematics that emphasizes reasoning, creative thinking, and problem-solving skills applied in different contexts

	particularly those that develop reasoning, creative thinking, and problem-solving skills applied in different contexts	that are essential in PISA.
⇒ Demonstrate knowledge and skills in varied approaches and methods of teaching mathematics	Demonstrate knowledge and skills in varied approaches and methods of teaching mathematics including those that develop reasoning, creative thinking, and problem-solving skills applied in different contexts	To promote teaching of mathematics that emphasizes reasoning, creative thinking, and problem-solving skills applied in different contexts that are essential in PISA.
⇒ Manifest discretion when selecting approaches or methods that would be effective in teaching particular lessons	Manifest discretion when selecting approaches or methods that would be effective in teaching and application of mathematics on financial planning, management, decision making and other real-life contexts (i.e., personal, occupational, societal and global)	To promote teaching and application of mathematics in financial context and other real-life contexts emphasized in PISA
⇒ Utilize a variety of student-centered approaches and methods in the classroom	Utilize a variety of both student-centered and collaborative social learning approaches and methods in the classroom.	To promote collaborative processes in the teaching of mathematics
⇒ Demonstrate skills in the use of common mathematical software for teaching and learning mathematical concepts, e.g., Graphmatica, GeoGebra and Geometer's Sketchpad	none	none
⇒ Develop and use materials that guide the students in	Develop and use materials that guide the students in using a	To make explicit the need to expose

using a mathematical software for discovering and learning mathematical concepts	mathematical software for discovering, learning, applying and interpreting mathematical concepts and processes (including software for computer simulation)	would-be mathematics teachers to activities using computer simulation in predicting outcomes
7. Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world.	Appreciate mathematics as an opportunity for problem solving, creative work, discovery and gaining insights of the world.	To remove redundant in the statement as the moment of enlightenment could be the same as discovery and gaining insight and to highlight problem solving as well as core process in mathematics literacy and creative thinking.
⇒ Model in class such mathematical attitudes as delight after having found the solution to a problem or a sense of wonder at how certain mathematical concepts evolved	Model in class such mathematical attitudes as delight after having found the solution to a problem in different contexts or a sense of wonder at how certain mathematical concepts and processes evolved	To make it explicit the need for mathematics processes developed in various contexts emphasized in PISA Mathematics and Financial Literacies
⇒ Develop lessons that can help students appreciate the use of mathematics in daily life	Develop lessons that can help students appreciate the use of mathematics in real-life contexts (i.e., personal, occupational, societal and global)	To make it explicit the need for mathematics in various contexts emphasized in PISA Mathematics and Financial Literacies

d. BSEd Major in Mathematics

Table 5.4 shows the proposed improvements in the course descriptions of the BSEd Major in Mathematics program to address the identified gaps based on PISA Frameworks.

Table 5.4

Recommended Revisions in the Course Description of Course in BSEd Major in Mathematics based on PISA Framework

Course Code	Course Title	Course Description Given in the CMO 75 s. 2017	Recommended Improvement based on PISA Framework
GEM	Mathematics in the Modern World	The course begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission and security and dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and testing the students' understanding and capacity.	The course begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning and problem solving in different contexts (i.e., personal, occupational, societal and global). The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as: managing personal, family, work, and societal finances; making social choices; appreciating geometric designs; understanding codes used in data transmission and security; and dividing limited resources fairly. These aspects will provide opportunities in doing mathematics individually or in teams in finding solutions to problems in finance and other contexts.

1. M100	History of Math	The course presents the humanistic aspects of mathematics which provides the historical context and timeline that led to the present understanding and applications of the different branches of mathematics.	The course presents the humanistic aspects of mathematics which provides the historical context and timeline that led to the present understanding and applications of the different branches of mathematics in various contexts. The course expects students to demonstrate their reasoning and problem-solving skills applied individually or in teams in various contexts to show development of one's mathematical and financial literacy and creative thinking.
2. M101	College and Advanced Algebra	The course builds upon the students' knowledge on properties of the real number system, operations on the different types of algebraic expressions, and the solution of various types of equations and inequalities. The course also covers the pre-requisites to trigonometry and calculus, specifically transcendental and non-transcendental functions, including the characteristics of their graphs and applications.	The course builds upon the students' knowledge on properties of the real number system, operations on the different types of algebraic expressions, and the solution of various types of equations and inequalities. The course develops student's reasoning and problem-solving skills applied individually or in teams in various contexts involving Algebra topics that are pre-requisites to trigonometry and calculus, specifically transcendental and non-transcendental functions, including the characteristics of their graphs and practical application of Algebra to matters related to finance, insurance, predicting risk and benefits, health and growth and decay, among others.

3. M102	Trigonometry	The course introduces the students to circular and trigonometric functions, trigonometric identities, and to the polar coordinate system. The students then apply concepts in these topics to application in problem solving.	The course introduces the students to circular and trigonometric functions, trigonometric identities, and to the polar coordinate system. The students then apply concepts, processes and skills in these topics in solving problems, individually, collaboratively and creatively.
4. M103	Plane and Solid Geometry	The course covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry.	The course covers topics on Euclidean Geometry and its applications in solving problems individually or in teams in various contexts. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry.
5. M104	Logic and Set Theory	The course is a study of mathematical logic which covers topics such as propositions, logical operators, rules of replacement, rules of inference, algebra of logic and quantifiers. It also includes a discussion of elementary theory of sets such as fundamental concepts of sets, set theorems and set operations.	The course is a study of mathematical logic which covers topics such as propositions, logical operators, rules of replacement, rules of inference, algebra of logic and quantifiers. It also develops student's creative thinking, reasoning, communication, and problem-solving skills applied individually or in teams in various contexts involving elementary theory of sets such as fundamental concepts of sets, set theorems, set operations and how these concepts are applied to social and scientific contexts. .

6. M105	Elementary Statistics and Probability	The course equips the students with the basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS.	The course equips the students with the basic statistical tools and software to understand various phenomena including growth phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields and contexts including finance and pandemic problems. With SPSS and other software, the course expects students to demonstrate with confidence and ease the ability to solve problems individually or in teams in various contexts that involve data interpretation, drawing of conclusion, and decision making
7. M106	Calculus 1 with Analytic Geometry	The course equips the students with knowledge and skills needed to be able to determine limits of functions to differentiate and to integrate algebraic, exponential, logarithmic, and trigonometric functions in one variable. It also includes exposures to more challenging problems covering continuity and areas of regions.	The course equips the students with knowledge and skills to determine limits of functions to differentiate and to integrate algebraic, exponential, logarithmic, and trigonometric functions in one variable. It also includes exposures to more challenging problems covering continuity and areas of regions applied in various contexts that necessitate reasoning, creative thinking and problem-solving skills either individually or in teams.

8. M107	Calculus 2	The course aims to further develop the students' understanding of differential and integral calculus. It covers the methods and techniques of integration, indeterminate forms, and improper integrals of algebraic and transcendental functions.	The course aims to further develop the students' understanding and applications of differential and integral calculus in solving problems individually or in teams. It covers the methods and techniques of integration, indeterminate forms, and improper integrals of algebraic and transcendental functions applied in various practical contexts.
9. M108	Calculus 3	The course aims to provide the students with an understanding of the applications of differentiation and integration in sequences, infinite series, power series, as well as of multiple integration for functions in several variables. Moreover, students will be able to apply these concepts to problem solving.	The course aims to provide the students with an understanding of the applications of differentiation and integration in sequences, infinite series, power series, as well as of multiple integration for functions in several variables. Moreover, students will be able to apply these concepts to individual and collaborative problem solving in various practical and useful contexts.
10. M109	Modern Geometry	The course is an enrichment of the course on Euclidean Geometry. It discusses the properties and applications of other types of geometries such as finite geometry, non-Euclidean geometry, and projective geometry.	The course is an enrichment of the course on Euclidean Geometry. It develops students' reasoning and problem-solving skills applied individually or in teams in various contexts involving properties and applications of other types of geometries such as finite geometry, non-Euclidean geometry, and projective geometry including geometric approximations.

11. M110	Mathematics of Investment	The course introduces students with a basic understanding of the applications of mathematical concepts and skills in economics, business and accounting. It includes determining the time value of money using simple and compound interest and discounting, variation of annuities, amortization, stocks and bonds, and sinking fund.	The course introduces students with a basic understanding of the applications of mathematical and financial concepts, processes and skills in economics, business, accounting from personal, occupational, societal and global contexts. It also develops students' reasoning and individual and collaborative problem-solving skills in various contexts involving value of money using simple and compound interest and discounting, variation of annuities, amortization, stocks and bonds, sinking fund, and computer simulation.
12. M111	Number Theory	The course is a study of the properties of numbers and their proofs. It presents the students with different methods of mathematical proving. It focuses on the discussion of the set of integers that include Unique Prime Factorization, Divisibility Rules, Euclidean Algorithm, Linear Congruences and Linear Diophantine Equations.	The course is a study of the properties of numbers and their proofs. It presents the students with different methods of mathematical proving. It develops students' reasoning and problem-solving skills applied individually or in teams in various contexts involving set of integers that include Unique Prime Factorization, Divisibility Rules, Euclidean Algorithm, Linear Congruences and Linear Diophantine Equations.
13. M112	Linear Algebra	The course provides a basic understanding of vector spaces, including the study of matrices, their properties and matrix operations. It also covers the applications of matrices in systems of	The course provides a basic understanding of vector spaces, including the study of matrices, their properties and matrix operations. It develops students' reasoning and problem-solving skills applied individually or in

		linear equations and linear transformations.	teams in various contexts involving matrices in systems of linear equations and linear transformations.
14. M113	Advanced Statistics	The course deals with non-parametric statistics. It covers the topics on test association such as Spearman Rho, Phi Coefficient, Contingency Coefficient, biserial and test of differences such as Mann-Whitney U, Wilcoxon. It includes applications and data analysis with computations carried out using SPSS.	The course deals with non-parametric statistics applied in various contexts including finance. It develops students' reasoning and problem-solving skills applied individually or in teams in various contexts that require a test of association using Spearman Rho, Phi Coefficient, Contingency Coefficient, biserial and test of differences such as Mann-Whitney U, Wilcoxon. It also provides students with hands-on experience in data analysis, interpretation and drawing conclusion caried out using SPSS.
15. M114	Problem Solving, Mathematical Investigation & Modeling	The course deepens and further enhances the students' understanding of real-life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.	The course deepens and enhances students' reasoning, creative thinking, and problem-solving skills in mathematics applied individually or in teams in real-life contexts including finance. The students apply mathematics in making investigations, pattern finding, testing and justifying conjectures, and generalizations in various contexts.
16. M115	Principles and Strategies in Teaching Mathematics	The course deals with the applications of the principles, the strategies in teaching, and philosophical foundations of teaching mathematics. These are then applied in	The course deals with the applications of the principles of learning, the strategies in teaching, and philosophical and social foundations of teaching mathematics. The students work individually or in

		lesson planning and microteaching.	teams in designing, implementation, evaluation and improvement of lesson plans in developing mathematical and financial literacies applied in various contexts.
17. M116	Abstract Algebra	The course is a study of basic algebraic structures such as groups, rings, integral domains and fields. It provides a basic understanding of relations focusing on isomorphism. It aims to enhance the student's skills in constructing mathematical proofs and develop their symbolic thinking and appreciation of mathematical structures.	The course is a study of basic algebraic structures such as groups, rings, integral domains and fields. It provides a basic understanding of relations focusing on isomorphism. It aims to enhance student's reasoning and problem-solving skills applied individually or in teams in various contexts involving construction of mathematical proofs, demonstration of symbolic thinking, and appreciation of mathematical structures.
18. M117	Research in Mathematics	The course aims to prepare prospective mathematics teachers to undertake an undergraduate research project. It gives teachers the opportunity to conduct various research that address problems, issues, and concerns in mathematics teaching and learning. It also showcases their research skills through the application of the mathematical content and processes they have learned previously.	The course aims to prepare prospective mathematics teachers to undertake an undergraduate research project. It gives students the opportunity to conduct research individually or in teams that address problems, issues, and concerns in mathematics teaching, learning, and assessment at the classroom to international level (e.g., Program in International Student Assessment). It also showcases their research skills through the application of the mathematical content and processes in finance and other contexts.

19. M118	Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics)	TTL2 is a 3-unit course which will focus on the application , design, production, utilization, and evaluation of information and Communications Technology (ICT) materials for teaching and learning in Mathematics Education Programs. The major requirement for this course is an ICT-integrated and Project-based Learning Plan aligned to the K to12 curriculum. All the learning activities and course requirements will revolve around the student-teacher developed Learning Plan.	TTL2 is a 3-unit course which will focus on the application , design, production, utilization, and evaluation of information and Communications Technology (ICT) materials in teaching and learning Mathematics including financial literacy. The major requirement for this course is an ICT-integrated and Project-based Learning Plan done individually or in teams that is compliant with the Kto12 curriculum and benchmarked with international standards including those emphasized in Program for International Student Assessment[(PISA). All the learning activities and course requirements will revolve around the student-teacher developed Learning Plan which integrates the PISA framework/features.
20. M119	Assessment and in Mathematics	The course deals with traditional and authentic assessment methods for evaluating mathematics learning. It covers the purposes of instruction and assessment, the relationship of assessment to content and performance standards, and discussions on the issues and trends in assessment specifically in mathematics teaching.	The course deals with traditional and authentic assessment methods for evaluating mathematics learning at the classroom, national and international levels. It covers the purposes of instruction and assessment, the relationship of assessment to content and performance standards, and discussions on the issues, trends, and challenges in assessment of mathematics learning brought about by the national and international large-scale assessments (ILSAs) that Philippines has

			participated in (e.g., PISA). The course expects would-be mathematics teachers to develop computer-based and paper-based classroom assessment done individually or in teams that is multidimensional such that it assesses content, processes, and 21st century skills learned in mathematics applied in finance and other real-life contexts similar to how PISA and other ILSAs are designed.

Given all the identified gaps in the BSEd program based on the challenges of PISA, the following strategies in addressing the gaps are recommended.

Recommendation # 1: **Revisit the Mathematics Teacher Education Program Framework**

The current PSGs for the BSEd program including that for the preparation of mathematics teachers in the secondary level need some updating and revision to accommodate latest developments in education including the challenges and directions posed by PISA and other ILSAs. There is a need to give emphasis on creativity, collaboration, and problem solving within the realm of the general, teacher education, and discipline-specific program outcomes and performance indicators as well as in the course descriptions of courses in the BSEd Major in Mathematics to address the found gaps in the program with reference to the framework of PISA as most countries in the world subscribe to such ILSA in improving their educational system.

Recommendation # 2 : **Place Emphasis on Core Mathematical Competencies**

As shown in Table 5.4, the course descriptions of all courses were improved to explicitly acknowledge the need to develop would-be mathematics teachers' reasoning and problem solving skills in each mathematics course. Reasoning and problem solving skills are not only valued in PISA mathematics literacy but also in the Kto12 mathematics curriculum. As pointed out in Balagtas et al. (2020), one of the directions of mathematics in PISA and Kto12 mathematics curriculum is the need to put premium on the development of reasoning and problem solving skills of students.

As problem solving is also a dimension of creative thinking, then scientific and social problem solving skills should also be developed in mathematics courses.

Recommendation # 3 : **Contextualize Mathematical Content and Processes**

As shown in Table 5.4, all the course descriptions of the 21 mathematics courses in the BSEd Major in Mathematics program were proposed to be improved to explicitly indicate the need to apply the content and processes of Mathematics courses in different contexts from personal, occupational, societal, and global/scientific as illustrated in the PISA Mathematics Literacy Framework. The mapping of the BSEd program outcomes, performance indicators, and courses and the analysis of alignment with the PISA Mathematics framework reveal that a gap appears in the lack of explicit coverage of context in the design of the BSEd program. Although contextualization in one's specialization 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 is still not explicit in the way BSEd Mathematics program outcomes are stated. This lack of emphasis on context is also evident in the way the course descriptions are written, hence the proposed revisions are provided in Table 5.4. The analysis of Golla and Reyes (2020), which compares how context is viewed in the Kto12 mathematics curriculum and in the PISA mathematics literacy framework, shows that the two documents view context in different perspectives. PISA mathematics framework emphasizes the need to apply mathematics in real-life contexts from personal to occupational, societal, and scientific. The Kto12 curriculum, on the other hand, defines context to refer to beliefs, environment, language, culture, and learner's prior knowledge. Even if there is an explicit reflection of context in the Kto12 mathematics framework, there is no clear articulation of how such context is actually put into practice as the statements of standards and competencies are not explicit on the integration of mathematics in various contexts. The study of Balagtas et al. (2020) also shares the same observation when the Kto12 mathematics curriculum is compared with SEA-PLM. Context is also an important dimension of this regional assessment, but it is not so much observed in the design of classroom assessments and even in instructional materials for basic education. This should be addressed in the curriculum for teacher preparation especially in the BSEd Major in Mathematics program, which as this study has pointed out, is also deficient. Hence, an explicit statement on the need to always put mathematics content and thinking processes including the 21st century skills in various contexts is the key to a stronger alignment between content and assessment.

Recommendation # 4 : **Strengthen Financial Literacy in Mathematics Courses**

As shown in Table 5.4, there are now eight (8) recommended courses that could help address competencies from the PISA financial literacy framework. The six (6) additional courses where financial literacy is proposed to be covered aside from the

two courses (i.e. *Mathematics in the Modern World* and *Mathematics Investigation*) are 1) Elementary Statistics and Probability; 2) Advanced Statistics; 3) Problem Solving, Mathematical Investigation & Modeling; 4) Principles and Strategies in Teaching Mathematics; 5) Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics); and 6) Assessment and Evaluation in Mathematics. Given that in the Kto12 Curriculum, one of the tracks in the Senior High School is Accountancy, Business and Management (DepEd, 2021) where financial literacy is reinforced, Mathematics specialists are expected to help deliver the said track. It is, therefore, necessary that the BSEd Mathematics program ensures that would-be mathematics teachers have a good foundational knowledge and skills in financial literacy and a good preparation as well when teaching mathematics and financial literacy to Junior High School students. As OECD (2019) has reported, based on PISA Financial Literacy Assessment in 2015, only 25% of the results are attributed uniquely to PISA literacy, while 75% is attributed to both mathematics and reading proficiency of the 15-year old learner. This means that good financial literacy is contingent upon one's proficiency in mathematics and reading. In the study of Yeban and Florendo (2020), however, they reported that the Kto12 curriculum in mathematics for Grades 7 to 10 has implicitly covered PISA financial literacy content, processes, and context by just about 21%. In this study, financial literacy is evidently not emphasized since only about 9% of the mathematics courses or two 3-unit courses (i.e. one general education course in Mathematics and one specialization course in mathematics) for a total of 6 units out of 66 units (i.e. 63 specialization courses plus the 3 units of General Education Mathematics) could explicitly cover financial literacy. Although financial literacy is not the only target of mathematics education, it is an essential literacy for 15-year old learners or for every citizen to acquire for them to effectively manage their financial problems in life, which is a key component of a successful life in the 21st century.

Recommendation # 5: **Explicitly Target Collaborative Problem Solving**

As shown in Table 5.4, the course descriptions of all courses were improved to explicitly acknowledge the need to develop individual and collaborative problem solving skills of would-be mathematics teachers. Development of problem solving skills is a core competency targeted in mathematics courses, but using that skill collaboratively with others to solve societal and global problems like discovering solutions to the global pandemic is still wanting. Thus, there is a need to equally develop both problem solving skills and collaborative problem solving skills among would-be mathematics teachers.

Recommendation # 6 : **Explicitly Target Creative Thinking in Mathematics**

As shown in Table 5.4 , the course descriptions were improved to also highlight the need to see mathematics as a venue for the development of would-be mathematics

teachers' creative thinking. Since creative thinking is the highest cognitive skill that could be acquired by any trained individual, this skill must be targeted in mathematics courses offered in teacher education programs.

Recommendation # 7: **Increase Awareness and Understanding of PISA Framework among Would-be Mathematics Teachers**

As shown in Table 5.4, there are three courses in the BSEd Major in Mathematics program where would-be mathematics teachers will get to understand the framework and features of ILSAs including PISA and the issues and challenges they pose in the education of secondary school learners. These courses are 1) Research in Mathematics; 2) Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics); and 3) Assessment and Evaluation in Mathematics.

CONCLUSIONS

The analysis of the responsiveness of the BSEd Major in Mathematics in meeting the demands of PISA as a benchmark of the effectiveness of the Kto12 program reveals important insights that could inform continuous updating of the teacher education program in the Philippines. The results confirm that the CHED mandated BSEd in Mathematics program has been designed to meet the content demands, cognitive processes, and 21st century skills emphasized in PISA mathematics. However, the program lacks emphasis on the application of mathematics in different contexts from personal to occupational, societal, and global settings as shown in the course descriptions in the CMO 75 s. 2017. This observation is consistent with how the mathematics curriculum for Grades 7 to 10 in basic education has been designed based on a prior study conducted by the author and her colleagues at the Philippine Normal University. This apparent lack of emphasis on the contextualization of mathematics could suggest deviation from what the CHED has envisioned in the Policies, Guidelines, and Standards of the BSEd program, which emphasizes achievement of the learning outcomes in the contexts and mission of the institution. In the advent of internationalization of teacher education to produce globally competitive professionals, there is a need for TE programs that meet both national and international standards. Hence, the framework of PISA, which is participated in by many countries (79 countries in 2018) is a good reference for the characteristics of an internationally-accepted curriculum, at least in a mathematics program for secondary education and teacher education. The gaps found in the BSEd Mathematics program, however, may suggest unpreparedness of would-be secondary mathematics teachers in the delivery of their courses. Thus, the need to address the gaps remains an important task for the TEIs.

Furthermore, the BSEd program also meets the demands of PISA Financial Literacy in terms of how the program outcomes and performance indicators are designed. The program has at least two specific courses where financial literacy content and processes are addressed. However, it also lacks emphasis particularly on the application of financial literacy in personal, family, and home contexts.

In terms of the PISA collaborative problem solving framework, the BSEd program also meets the expectations to a certain extent in how the general and teacher education program outcomes are stated. However, the BSEd program fails to explicitly target the CPS processes defined in PISA. Problem solving, which is one course in the BSEd program, does not even explicitly target the need for would-be mathematics teachers to develop their ability to solve problems collaboratively with others, which PISA emphasizes.

Finally, the BSEd program meets the content and competencies of PISA creative thinking in how the teacher education program outcomes are stated. However, it does not explicitly cover the requirements of creative thinking in how the general program outcomes, mathematics program outcomes, performance indicators, and course descriptions are expressed. It appears that the program lacks explicit coverage of the development of written and visual creative expressions and creative social problem solving as well as the competencies in generating diverse ideas and in evaluating and improving ideas, which are all valued in PISA Creative Thinking Framework.

RECOMMENDATIONS

The foregoing conclusions on how responsive the BSEd Major in Mathematics is in preparing the mathematics teachers in the secondary schools in the Philippines to meet the challenges of PISA yielded several recommendations for the improvement of mathematics teacher education. These recommendations are primarily on the needed updating of the policies, standards, guidelines, and framework of the Bachelor in Secondary Education Major in Mathematics program and how such program should be updated as well by the Teacher Education Institutions to produce would-be mathematics teachers who are prepared to deliver mathematics lessons to the secondary school learners that meet the proficiency set in PISA mathematics literacy.

First, there is a need for CHED to **update the CMO 75 s. 2017 on the Policies, Standards, and Guidelines** to make it responsive to the demands of PISA and other ILSAs that the Philippines participated in order to gather indicators of the effectiveness

of the quality reform programs in the country's educational system. *Second,* for the TEIs to **review and contextualize their own curricular program offerings in the preparation of mathematics teachers** to ensure meeting national and global standards particularly the demands of PISA, which is a good reference for the improvement of educational systems. There is a need for the deepening of would-be mathematics teachers' content knowledge, cognitive processes, and 21st century skills and how they are applied in various contexts from personal to occupational, societal and global contexts. *Third,* there is a need to **strengthen financial literacy education in the mathematics teacher preparation** to ensure that would-be mathematics teachers have a good foundational knowledge and skills in financial literacy to effectively teach the same to 15-year old learners or for every citizen to manage effectively their financial problems in life, which is a key component of a successful life in this 21st century. *Fourth*, there is a need to **explicitly target the development of would-be mathematics teachers' collaborative problem solving skills** that PISA values much. Development of problem solving skills is a core competency targeted in mathematics courses, but using that skill collaboratively with others in solving societal and global problems like in discovering solutions to the global pandemic remains to be seen in the curriculum documents. Hence, the need to equally develop problem solving skills and collaborative problem solving skills among would-be mathematics teachers. *Fifth,* **explicitly target creative thinking in the preparation of mathematics teachers** as creative thinking is needed in solving personal, occupational, societal, and global problems. *Sixth,* **increase awareness and understanding of would-be mathematics teachers and teacher educators on the impact of PISA** in addressing the issues and challenges confronting the learning crisis in the Philippines. *Lastly,* for the CHED and TEIs to consider the recommended improvements in the statements of general program outcomes, teacher education program outcomes, discipline-specific program outcomes, and performance indicators in the BSEd Mathematics program including the suggested refinements in the course descriptions presented in CMO 75 s. 2017 to address the identified gaps in the lens of the PISA challenges.

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Appendix A

Curriculum Analysis Matrix for BSEd Major in Mathematics

A. BSEd General Program Outcomes

CMO on BSEd		PISA Components to Map
Code	**Statement of Program Outcomes**	
CMOPOG10	**Common to all programs in all types of schools**	
	The graduates have the ability to:	
CMOPOG11	articulate and discuss the latest developments in the specific field of practice (PQF level 6 descriptor)	
CMOPOG12	effectively communicate in English and Filipino, both orally and in writing	
CMOPOG13	work effectively and collaboratively with substantial degree of independence in multi-disciplinary and multi-cultural teams (PQF level 6 descriptor)	
CMOPOG14	act in recognition of professional, social, and ethical responsibility	
CMOPOG15	preserve and promote "Filipino historical and cultural heritage (based on RA 7722)	

B. BSEd Teacher Education Outcomes

CMO on BSEd		PISA Components to Map
Code	**Statement of Program Outcomes**	
CMOPOTE20	**Common to all disciplines (Teacher Education)**	
	The graduates have the ability to:	
CMOPOTE21	articulate the rootedness of education in philosophical, socio-cultural, historical, psychological, and political contexts	
CMOPOTE22	demonstrate mastery of the subject matter/discipline	
CMOPOTE23	facilitate learning using a wide range of teaching methodologies and delivery modes appropriate to specific learners and their environment	
CMOPOTE24	develop innovative curricula, instructional plans, teaching approaches, and resources for diverse learners	
CMOPOTE25	apply skills in the development and utilization of ICT to promote quality, relevant, and sustainable educational practices	
CMOPOTE26	demonstrate a variety of thinking skills in planning, monitoring, assessing, and reporting learning processes and outcomes	
CMOPOTE27	practice professional and ethical teaching standards sensitive to local, national and global realities	
CMOPOTE28	pursue lifelong learning for personal and professional growth through varied experiential and field-based opportunities	

C. BSEd Major in Mathematics Program Outcomes and Performance Indicators

CMO on BSEd Major in Mathematics			PISA Components to Map
Code	**Program Outcomes**	**Performance Indicators**	
CMOPOTEM331	Exhibit competence in mathematical concepts and procedures		
CMOPOTEPIM3311		Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed	
CMOPOTEPIM3312		Demonstrate in detail basic mathematical procedures	
CMOPOTEPIM3313		Show the connections between mathematical concepts that are related to one another	
CMOPOTEPIM3314		Provide examples to illustrate the application of mathematical concepts and procedures	
CMOPOTEM332	Exhibit proficiency in relating mathematics to other curricular areas		
CMOPOTEPIM3321		Create a curriculum guide that shows how mathematics can be integrated with other curricular areas	
CMOPOTEPIM3322		Identify teaching activities which support the implementation of the curriculum guide	
CMOPOTEPIM3323		Develop and utilize instructional materials that support the integration of mathematics with other curricular areas	
CMOPOTEPIM3324		Utilize appropriate technologies to achieve the learning outcomes	
CMOPOTEM333	Manifest meaningful and comprehensive pedagogical content knowledge (PCK) of mathematics		
CMOPOTEPIM3331		Demonstrate skills in various methods of learning in mathematics such as, conducting investigations, modeling, and doing research	
CMOPOTEPIM3332		Create and utilize learning experiences in the classroom which develop the learners'	

		skills in discovery learning, problem solving and critical thinking	
CMOPOTEM334	Demonstrate competence in designing, constructing, and utilizing different forms of assessment in mathematics		
CMOPOTEPIM3341		Design and utilize varied assessment tools in mathematics, including alternative forms of assessment	
CMOPOTEPIM3342		Analyze assessment results and use these to improve learning and teaching	
CMOPOTEPIM3343		Provide timely feedback of assessment results to students	
CMOPOTEM335	Demonstrate proficiency in problem solving by solving and creating routine and non-routine problems with different levels of complexity		
CMOPOTEPIM3351		Demonstrate skills in various problem solving heuristics	
CMOPOTEPIM3352		Select suitable examples to explain the various problem-solving heuristics	
CMOPOTEPIM3353		Manifest creativity and critical thinking when selecting examples and problems to be used in the classroom and in the assessment of students learning	
CMOPOTEPIM3354		Use varied resources for selecting and creating problems to develop the students' problem-solving skills	
CMOPOTEM336	Use effectively appropriate approaches, methods, and techniques in teaching mathematics including technological tools		
CMOPOTEPIM3361		Demonstrate knowledge and skills in varied approaches and methods of teaching mathematics	
CMOPOTEPIM3362		Manifest discretion when selecting approaches or methods that would be effective in teaching particular lessons	

CMOPOTEPIM3363		Utilize a variety of student-centered approaches and methods in the classroom	
CMOPOTEPIM3364		Demonstrate skills in the use of common mathematical software for teaching and learning mathematical concepts, e.g., Graphmatica, GeoGebra and Geometer's Sketchpad	
CMOPOTEPIM3365		Develop and use materials that guide the students in using a mathematical software for discovering and learning mathematical concepts	
CMOPOTEM337	Appreciate mathematics as an opportunity for creative work, moments of enlightenment, discovery and gaining insights of the world.		
CMOPOTEPIM3371		Model in class such mathematical attitudes as delight after having found the solution to a problem or a sense of wonder at how certain mathematical concepts evolved	
CMOPOTEPIM3372		Develop lessons that can help students appreciate the use of mathematics in daily life	

D. **BSEd Mathematics Courses and Course Descriptions**

Code	Course Title	No. of Units	Course Descriptions	PISA Components to Map
A. General Education Mathematics (3 Units)				
GEM	Mathematics in the Modern World	3	The course begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission and security and	

			dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and test the students' understanding and capacity.	
B. Mathematics Major Courses (63 Units)				
M100	History of Math	3	The course presents the humanistic aspects of mathematics which provides the historical context and timeline that led to the present understanding and applications of the different branches of mathematics.	
M101	College and Advanced Algebra	3	The course builds upon the students' knowledge on properties of the real number system, operations on the different types of algebraic expressions, and the solution of various types of equations and inequalities. The course also cover the pre-requisites to trigonometry and calculus, specifically transcendental and non-transcendental functions, including the characteristics of their graphs and applications.	
M102	Trigonometry	3	The course introduces the students to circular and trigonometric functions, trigonometric identities, and to the polar coordinate system. The students then apply concepts in these topics to application in problem solving.	
M103	Plane and Solid Geometry	3	The course covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry.	
M104	Logic and Set Theory	3	The course is a study of mathematical logic which covers topics such as propositions, logical operators, rules of replacement, rules of inference, algebra of logic and quantifiers. It also includes a discussion of elementary theory of sets such as fundamental concepts of sets, set theorems and set operations.	
M105	Elementary	3	The course equips the students with the	

	Statistics and Probability		basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS.	
M106	Calculus 1 with Analytic Geometry	4	The course equips the students with knowledge and skills needed to be able to determine limits of functions to differentiate and to integrate algebraic, exponential, logarithmic, and trigonometric functions in one variable. It also includes exposures to more challenging problems covering continuity and areas of regions.	
M107	Calculus 2	4	The course aims to further develop the students' understanding of differential and integral calculus. It covers the methods and techniques of integration, indeterminate forms, and improper integrals of algebraic and transcendental functions.	
M108	Calculus 3	3	The course aims to provide the students with an understanding of the applications of differentiation and integration in sequences, infinite series, power series, as well as of multiple integration for functions in several variables. Moreover, students will be able to apply these concepts to problem solving.	
M109	Modern Geometry	3	The course is an enrichment of the course on Euclidean Geometry. It discusses the properties and applications of other types of geometries such as finite geometry, non-Euclidean geometry, and projective geometry.	
M110	Mathematics of Investment	3	The course introduces students with a basic understanding of the applications of mathematical concepts and skills in economics, business and accounting. It includes determining the time value of money using simple and compound interest and discounting, variation of	

			annuities, amortization, stocks and bonds, and sinking fund.	
M111	Number Theory	3	The course is a study of the properties of numbers and their proofs. It presents the students with different methods of mathematical proving. It focuses on the discussion of the set of integers that include Unique Prime Factorization, Divisibility Rules, Euclidean Algorithm, Linear Congruences and Linear Diophantine Equations.	
M112	Linear Algebra	3	The course provides a basic understanding of vector spaces, including the study of matrices, their properties and matrix operations, It also covers the applications of matrices in systems of linear equations and linear transformations.	
M113	Advanced Statistics	3	The course deals with non-parametric statistics. It covers the topics on test association such as Spearman Rho, Phi Coefficient, Contingency Coefficient, biserial and test of differences such as Mann-Whitney U, Wilcoxon. It includes applications and data analysis with computations caried out using SPSS.	
M114	Problem Solving, Mathematical Investigation & Modeling	3	The course deepens and further enhances the students' understanding of real life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.	
M115	Principles and Strategies in Teaching Mathematics	3	The course deals with the applications of the principles, the strategies in teaching, and philosophical foundations of teaching mathematics. These are then applied in lesson planning and microteaching.	
M116	Abstract Algebra	3	The course is a study of basic algebraic structures such as groups, rings, integral domains and fields. It provides a basic understanding of relations focusing on isomorphism. It aims to enhance the student's skills in constructing mathematical proofs, and develop their symbolic thinking and appreciation of mathematical structures.	

M117	Research in Mathematics	4	The course aims to prepare prospective mathematics teachers to undertake an undergraduate research project. It gives teachers the opportunity to conduct researches that address problems, issues, and concerns in mathematics teaching and learning. It also showcases their research skills through the application of the mathematical content and processes they have learned previously.	
M118	Technology for Teaching and Learning 2 (Instrumentation and Technology in Mathematics)	3	TTL2 is a 3-unitc course which will focus on the application , design, production, utilization, and evaluation of information and Communications Technology (ICT) materials for teaching and learning in Mathematics Education Programs. The major requirement for this course is an ICT-integrated and Project-based Learning Plan aligned to the K to12 curriculum. All the learning activities and course requirements will revolve around the student-teacher developed Learning Plan.	
M119	Assessment and Evaluation in Mathematics	3	The course deals with traditional and authentic assessment methods for evaluating mathematics learning. It covers the purposes of instruction and assessment, the relationship of assessment to content and performance standards, and discussions on the issues and trends in assessment specifically in mathematics teaching.	

Appendix B

Results on the Validation of the Study by Expert Reviewers

Expert Reviewer 1 (37-Year Mathematics Educator): Comments on the Alignment of the PISA Content Domains vis-a-vis BSEd Mathematics Courses based on Course Descriptions

Table 1.9

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

Domain Code	PISA 2021 Mathematics Content Domains	Topics Covered (Golla & Reyes, 2020)	BSEd Content Courses in Math (CMO 75 s.2017)	Validator's Feedback	Researcher's Actions
Content 1	Space and Shape	Geometric Approximations; Spatial Visualization; Measurement; and Algebra	Geometry; Trigonometry; Algebra; Mathematics in the Modern World; Problem Solving, Mathematical Investigation & Modeling; Technology for Teaching and Learning	Please include Calculus	Implemented the recommendation in Table 1.9
Content 2	Change and Relationship	Algebraic Expressions and Functions; Equations and Inequalities; Algebra in Growth Phenomena; Relationship between & Among Geometrical Objects	Algebra; Geometry; Calculus; and Problem Solving, Mathematical Investigation & Modeling; Statistics and Probability; Advanced Statistics;	Please include Trigonometry, Number Theory Linear Algebra (systems of linear equations), and Math of Investment.	Implemented the recommendation in Table 1.9
Content 3	Uncertainty and Data	Counting Principles; Probability in Predicting Events; Sampling; Data Collection; and Measures of Central Tendency and Variability	Statistics and Probability; Advanced Statistics; Mathematics Investment; Problem Solving; Mathematical Investigation & Modeling		
Content 4	Quantity	Making Sense of Data; Statistics in Decision Making; Measurement; Estimation; Number and Number Sense; Numerical Trends and Patterns; Computer Simulation on Complex Problems	Statistics and Probability; Advanced Statistics; Algebra; Geometry; Mathematics in the Modern World; Logic and Set Theory; Mathematics Investment; Number Theory; and Technology for Teaching and Learning	Please include Trigonometry, Calculus, Linear Algebra, and Problem Solving, Math Investigation and Modelling. Also, for me, Logic and Set Theory should not be included because I could not see any cue word in the course description that implies alignment	Implemented the recommendation in Table 1.9

				with content in PISA as identified by Golla and Reyes.	

Expert Reviewer's Working Table Showing Basis for Recommendations

Course Code	Reference	Cue Words			
		Content 1	Content 2	Content 3	Content 4
Math 102 Trigonometry	PISA				Measurement, Estimation
	Course Description				Application of Trigonometric Functions
Math 106 Calculus 1 with Analytic Geometry	PISA	Spatial Visualization; Geometry			
	Course Description	Areas and Volumes			
Math 108 Calculus 3	PISA				Numerical Trends and Patterns
	Course Description				Sequences
Math 110 Mathematics of Investment	PISA		Algebra in Growth Phenomena		
	Course Description		simple and compound interest and discounting, variation of annuities, amortization, stocks and bonds, and sinking fund		
Math 111 Number Theory	PISA		Equations and Inequalities		
	Course Description		Linear Diophantine Equations, Congruence		
Math 112 Linear Algebra	PISA		Equations		Numbers and Number Sense
	Course Description		Systems of Equations		Matrix Operations
Math 114 Problem Solving, Mathematical Investigation and Modeling	PISA				Numerical Trends and Patterns
	Course Description				Pattern Finding

Expert Reviewer Analysis of the Alignment of the BSE Major in Mathematics Courses vis-à-vis Context Requirements of PISA 2021 Mathematics Literacy

BSE Major in Mathematics Courses		Expert Validator's Comments on the PISA 2021 Mathematics Contexts Domain				Researcher's Actions
Code	Title	Personal (Context 1)	Occupational (Context 2)	Societal (Context 3)	Scientific (Context 4)	
1. GEM	Mathematics in the Modern World	✓		✓	✓	
2. M100	History of Math	✓ (Not explicitly reflected in the course description				Retained because of the word "humanistic" in the course descriptions which could be categorized as personal context
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		✓		✓ (Not explicitly reflected in the course description	Retained because of the word "SPSS" which is a statistical software that is considered under scientific based on PISA definition of scientific context.
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				✓ (Not explicitly reflected in the course description	Retained because of the word "SPSS" which is a statistical software that is considered under scientific based on PISA definition of scientific context.
16. M114	Problem Solving, Mathematical Investigation & Modeling		X (Not explicitly reflected in the course description		✓	The researcher changed the classification from occupational to scientific context because of the phrase "…real-life applications of mathematics through investigating, pattern finding, testing, and justifying conjectures and making generalizations" in the course description.
17. M115	Principles and Strategies in Teaching Mathematics		✓			
18. M116	Abstract Algebra					
19. M117	Research in Mathematics		✓ (Not explicitly reflected in the course description)			Retained because of the words " conduct research that address problems, issues, concerns in mathematics teaching…" which is indicative of occupational context.
20. M118	Technology for Teaching and Learning 2 (Instrumentation and		✓		✓ (Not explicitly reflected in the course description)	Retained because of the word "ICT" which refers to technology that is considered under scientific based on PISA definition of scientific context.

	Technology in Mathematics)					
21. M119	Assessment and Evaluation in Mathematics		✓			
Total	**21**	**2**	**6**	**2**	**4**	

Expert Reviewer 2 (14-Year Mathematics Educator): Comments on the Alignment of the PISA Content Domains vis-a-vis BSEd Mathematics Courses based on Course Descriptions

PISA 2021 Mathematics Content Domains/Code	PISA Topics Covered (Golla & Reyes, 2020)	BSEd Content Courses in Math (CMO 75 s.2017)	Course Descriptions	Alignment with PISA of BSEd Content Courses	Researcher's Actions
Content 1: Space and Shape	Geometric Approximations; Spatial Visualization; and Algebra	GEM: Mathematics in the Modern World	The course begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission and security and dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and test the students' understanding and capacity.	exploration of (number/geometric) patterns	Retained the alignment
		M101: College and Advanced Algebra	The course builds upon the students' knowledge on properties of the real number system, operations on the different types of algebraic expressions, and the solution of various types of equations and inequalities. The course also covers the pre-requisites to trigonometry and calculus, specifically transcendental and non-transcendental functions, including the	it is not explicitly stated in the course description but examples of geometric patterns can be easily used	Retained the alignment
		M102: Trigonometry	The course introduces the students to circular and trigonometric functions, trigonometric identities, and to the polar coordinate system. The students then apply concepts in these topics to application in problem solving.	circular and trigonometric functions	Retained the alignment
		M103: Plane and Solid Geometry	The course covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry.	the entire course description	Retained the alignment

		M112: Linear Algebra	The course provides a basic understanding of vector spaces, including the study of matrices, their properties and matrix operations, It also covers the applications of matrices in systems of linear equations and linear transformations.	can be included in specific examples in the course, however, the level of knowledge presented here is not what was intended by PISA, that is not for 15 year-old-learners	Retained the alignment
		M114: Problem Solving, Mathematical Investigation & Modeling	The course deepens and further enhances the students' understanding of real life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.	pattern finding	Retained the alignment
		M116: Abstract Algebra	The course is a study of basic algebraic structures such as groups, rings, integral domains and fields. It provides a basic understanding of relations focusing on isomorphism. It aims to enhance the student's skills in constructing mathematical proofs, and develop their symbolic thinking and appreciation of mathematical structures.	this is not aligned with PISA because of the level of its abstraction	Removed in the alignment
		M118: Technology for Teaching and Learning	TTL2 is a 3-unitc course which will focus on the application, design, production, utilization, and evaluation of information and Communications Technology (ICT) materials for teaching and learning in Mathematics Education Programs. The major requirement for this course is an ICT-integrated and Project-based Learning Plan aligned to the K to12 curriculum. All the learning activities and course requirements will revolve around the student-teacher developed Learning Plan.	not explicitly stated but can easily cover PISA	Retained the alignment
Content 2: Change and Relationship	Algebraic Expressions and Functions; Equations and Inequalities; Algebra in Growth Phenomena; Relationship Between & Among Geometrical Objects	M101: College and Advanced Algebra	The course builds upon the students' knowledge on properties of the real number system, operations on the different types of algebraic expressions, and the solution of various types of equations and inequalities. The course also covers the pre-requisites to trigonometry and calculus, specifically transcendental and non-transcendental functions, including the characteristics of their graphs and applications.	entire course description	Retained the alignment
		M102: Trigonometry	The course introduces the students to circular and trigonometric functions, trigonometric identities, and to the polar coordinate system. The students then apply concepts in these topics to application in problem solving.	entire course description	Retained the alignment
		M103: Plane and Solid Geometry	The course covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry.	present in some corollaries, postulates and theorems	Retained the alignment

		M105: Statistics and Probability	The course equips the students with the basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS.	entire course description	Retained the alignment
		M106: Calculus 1 with Analytic Geometry	The course equips the students with knowledge and skills needed to be able to determine limits of functions to differentiate and to integrate algebraic, exponential, logarithmic, and trigonometric functions in one variable. It also includes exposures to more challenging problems covering continuity and areas of regions.	can be included in specific examples in the course, however, the level of knowledge presented here is not what was intended by PISA, that is not for 15 year-old-learners	Retained the alignment
		M107: Calculus 2	The course aims to further develop the students' understanding of differential and integral calculus. It covers the methods and techniques of integration, indeterminate forms, and improper integrals of algebraic and transcendental functions.	can be included in specific examples in the course, however, the level of knowledge presented here is not what was intended by PISA, that is not for 15 year-old-learners	Retained the alignment
		M108: Calculus 3	The course aims to provide the students with an understanding of the applications of differentiation and integration in sequences, infinite series, power series, as well as of multiple integration for functions in several variables. Moreover, students will be able to apply these concepts to problem solving.	can be included in specific examples in the course, however, the level of knowledge presented here is not what was intended by PISA, that is not for 15 year-old-learners	Retained the alignment
		M109: Modern Geometry	The course is an enrichment of the course on Euclidean Geometry. It discusses the properties and applications of other types of geometries such as finite geometry, non-Euclidean geometry, and projective geometry.	entire course description however the level of knowledge presented here is not was intended by PISA, that is not for 15 years old learners	Retained the alignment
		M110: Mathematics of Investment	The course introduces students with a basic understanding of the applications of mathematical concepts and skills in economics, business and accounting. It includes determining the time value of money using simple and compound interest and discounting, variation of annuities, amortization, stocks and bonds, and sinking fund.	entire course description	Retained the alignment

		M111: Number Theory	The course is a study of the properties of numbers and their proofs. It presents the students with different methods of mathematical proving. It focuses on the discussion of the set of integers that include Unique Prime Factorization, Divisibility Rules, Euclidean Algorithm, Linear Congruences and Linear Diophantine Equations.	present in some corollaries, postulates and theorems however the level of knowledge presented here is not what was intended by PISA, that is not for 15-year- old learners	Retained the alignment
		M112: Linear Algebra	The course provides a basic understanding of vector spaces, including the study of matrices, their properties and matrix operations, It also covers the applications of matrices in systems of linear equations and linear transformations.	the entire course however the level of knowledge presented here is not was intended by PISA, that is not for 15 years old learners	Retained the alignment
		M113: Advanced Statistics	The course deals with non-parametric statistics. It covers the topics on test association such as Spearman Rho, Phi Coefficient, Contingency Coefficient, biserial and test of differences such as Mann-Whitney U, Wilcoxon. It includes applications and data analysis with computations caried out using SPSS.	the entire course description	Retained the alignment
		M114: Problem Solving, Mathematical Investigation & Modeling	The course deepens and further enhances the students' understanding of real-life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.	the entire course description	Retained the alignment
		M116: Abstract Algebra	The course is a study of basic algebraic structures such as groups, rings, integral domains and fields. It provides a basic understanding of relations focusing on isomorphism. It aims to enhance the student's skills in constructing mathematical proofs, and develop their symbolic thinking and appreciation of mathematical structures.	this is not aligned with PISA because of the level of its abstraction	Removed in the alignment
Content 3: Uncertainty of Data	Counting Principles; Probability in Predicting Events; Sampling; Data Collection; and Measures of Central Tendency and Variability	M105: Statistics and Probability	The course equips the students with the basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS.	the entire course description	Retained the alignment
		M110: Mathematics of Investment	The course introduces students with a basic understanding of the applications of mathematical concepts and skills in economics, business and accounting. It includes determining the time value of money using simple and compound interest and discounting, variation of annuities, amortization, stocks and bonds, and sinking fund.	stocks and bonds	Retained the alignment

		M113: Advanced Statistics	The course deals with non-parametric statistics. It covers the topics on test association such as Spearman Rho, Phi Coefficient, Contingency Coefficient, biserial and test of differences such as Mann-Whitney U, Wilcoxon. It includes applications and data analysis with computations caried out using SPSS.	the entire course description	Retained the alignment
		M114: Problem Solving, Mathematical Investigation & Modeling	The course deepens and further enhances the students' understanding of real-life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.	the entire course description	Retained the alignment
Content 4: 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	The course begins with the introduction to the nature of mathematics as an exploration of patterns (in nature and the environment) and as an application of inductive and deductive reasoning. The course then proceeds to survey ways in which mathematics provides a tool for understanding and dealing with various aspects of present day living such as managing personal finances, making social choices, appreciating geometric designs, understanding codes used in data transmission and security and dividing limited resources fairly. These aspects will provide opportunities for actually doing mathematics in a broad range of exercises that bring out the various dimensions of mathematics as a way of knowing and test the students' understanding and capacity.	the entire course description	Retained the alignment
		M101: College and Advanced Algebra	The course builds upon the students' knowledge on properties of the real number system, operations on the different types of algebraic expressions, and the solution of various types of equations and inequalities. The course also covers the pre-requisites to trigonometry and calculus, specifically transcendental and non-transcendental functions, including the	the entire course description	Retained the alignment
		M102: Trigonometry	The course introduces the students to circular and trigonometric functions, trigonometric identities, and to the polar coordinate system. The students then apply concepts in these topics to application in problem solving.	the entire course description	Retained the alignment
		M103: Plane and Solid Geometry	The course covers topics on Euclidean Geometry. The topics are discussed using both the deductive and inductive methods to conjecture definitions, corollaries, postulates and theorems on plane and solid geometry.	the entire course description	Retained the alignment

		M105: Statistics and Probability	The course equips the students with the basic statistical tools to understand various phenomena. The topics on mean, variance, sampling, and estimation eventually allow the students to be able to perform hypothesis testing on real-life problems from different fields. The course includes applications and data analysis with computations carried out using SPSS.	the entire course description	Retained the alignment
		M106: Calculus 1 with Analytic Geometry	The course equips the students with knowledge and skills needed to be able to determine limits of functions to differentiate and to integrate algebraic, exponential, logarithmic, and trigonometric functions in one variable. It also includes exposures to more challenging problems covering continuity and areas of regions.	the entire course description	Retained the alignment
		M108: Calculus 3	The course aims to provide the students with an understanding of the applications of differentiation and integration in sequences, infinite series, power series, as well as of multiple integration for functions in several variables. Moreover, students will be able to apply these concepts to problem solving.	entire course description however the level of knowledge presented here is not was intended by PISA, that is not for 15 years old learners	Retained the alignment
		M110: Mathematics of Investment	The course introduces students with a basic understanding of the applications of mathematical concepts and skills in economics, business and accounting. It includes determining the time value of money using simple and compound interest and discounting, variation of annuities, amortization, stocks and bonds, and sinking fund.	the entire course description	Retained the alignment
		M111: Number Theory	The course is a study of the properties of numbers and their proofs. It presents the students with different methods of mathematical proving. It focuses on the discussion of the set of integers that include Unique Prime Factorization, Divisibility Rules, Euclidean Algorithm, Linear Congruences and Linear Diophantine Equations.	the entire course description	Retained the alignment
		M112: Linear Algebra	The course provides a basic understanding of vector spaces, including the study of matrices, their properties and matrix operations, It also covers the applications of matrices in systems of linear equations and linear transformations.	the entire course however the level of knowledge presented here is not was intended by PISA, that is not for 15 years old learners	*Retained the alignment*
		M113: Advanced Statistics	The course deals with non-parametric statistics. It covers the topics on test association such as Spearman Rho, Phi Coefficient, Contingency Coefficient, biserial and test of differences such as Mann-Whitney U, Wilcoxon. It includes applications and data analysis with computations caried out using SPSS.	the entire course description	*Retained the alignment*

		M114: Problem Solving, Mathematical Investigation & Modeling	The course deepens and further enhances the students' understanding of real-life applications of mathematics through investigating, pattern finding, testing and justifying conjectures, and making generalizations.	the entire course description	*Retained the alignment*
		M118: Technology for Teaching and Learning	TTL2 is a 3-unitc course which will focus on the application, design, production, utilization, and evaluation of information and Communications Technology (ICT) materials for teaching and learning in Mathematics Education Programs. The major requirement for this course is an ICT-integrated and Project-based Learning Plan aligned to the K to12 curriculum. All the learning activities and course requirements will revolve around the student-teacher developed Learning Plan.	the entire course description	*Retained the alignment*

Expert Reviewer 3 (36-Year Mathematics Educator): Comments on the Whole Report

Area Commented	Expert Reviewer # 3 Comments	Action Taken by the Researcher
Framework of Mathematics Literacy in PISA 2021, 4th paragraph on p. 46	The line … every item could provide four information as there are four different dimensions covered as shown in Figure 1 Could be better stated as: …every item could provide various information across four different dimensions as shown in Figure 1	Rephrased by the language editor as: ... every item could provide four information since there are four different dimensions covered as shown in Figure 1. This improvement by the editor was adopted by the researcher.
Relationship of Financial Literacy with Mathematics Literacy, 5th paragraph, page 8	Clarify the sentence that says that there are content knowledge in financial literacy that are independent of mathematics.	Revised the sentence to make it clear that there is content knowledge in financial literacy that do not involve arithmetic and vice versa.
Statement of the Problem	Problem 1 could be reworded as 1. How aligned are the program outcomes, performance indicators, and courses in the BSEd-Mathematics defined in CHED Memo No. 75. Series of 2017 to the demands of PISA in the following areas of assessment? a. mathematics literacy b. financial literacy c. collaborative problem solving d. creative thinking Then qualify that program outcomes are levelled (or categorized) to the general degree program, teacher education degree program and the discipline-specific program BSEd major in Mathematics.	Rephrased the problems following the suggestion of the reviewer.
Results and Discussion	It appears that the discussion on alignment of the PISA Mathematics Core Process vis-à-vis the Program Outcomes (general education, teachers education, BSEd Mathematics) were based on the researcher's judgment but there was peer review stated in the methodology. Please add on how peer review was done, how many reviewers, how the differences and consensus with the researcher's analysis were addressed and how they were treated and accommodated in the final analysis as presented in Tables 1.1. It appears that they are solely the researcher's own analysis. Just mention before presenting results on Table 1.1 to Table 1.4, if these are all just researcher's analysis.	The researcher indicated in Tables 1.1. to 1.4 that the data were just based on the researcher's analysis but reviewed by the subject area specialists. She also indicated in the methodology that she was the only analyst of the mapping of the documents, but the expert reviewers checked her mapping as well.
PISA Financial Literacy Framework	Add a sentence or two to explain the two-pronged analysis done with the BSEd mathematics program and PISA 2021 literacy framework	The researcher provided the additional sentences to explain what she meant with the two-

		pronged analyses of the BSEd mathematics program and PISA 2021 mathematics literacy framework
Discussion of Results in Table 1.1	Expand a little more the presentation of results in Table 1.1	The researcher elaborated more the discussion of the results as suggested by the reviewer.
Table 1.7	Why put the program outcomes not aligned to PISA to be in the footnote of the table for the findings? What are these program outcomes? Those program outcomes of BSEd that were not aligned means that… (or expected for what reason?	The researcher added a line in the discussion of results to explain that the other statements of outcomes do not explicitly match with the PISA core processes. The researcher also kept the note below the table that some of the program outcomes in the BSEd curriculum are not necessarily aligned with PISA. For more details, the readers were also directed to the Appendix where they could see the complete statements of program outcomes in the BSEd curriculum.
Table 1.8	Check if the performance indicator "Explain and illustrate clearly, accurately, and comprehensively the basic mathematics concepts, using relevant examples as needed" has no corresponding match under formulating and employing.	The researcher re-analyzed the alignment and identified one (1) formulating process and another one (1) employing process that could represent the given performance indicator.
Inconsistency in the Use of BSEd and BSE	There are parts observed where these acronyms of BSEd and BSE were alternately used although they have the same meaning.	The author/researcher used the acronym BSEd consistently throughout the whole manuscript.
Table 1.10	I wonder if the course description was enough to see how the courses were contextualized in the various aspect of personal, occupational, etc. If the analysis of the alignment moved deeper to examining the course syllabus with list of competencies, could there be more check marks in this table?	The researcher indicated in the Methodology the limitations of the study that it only analyzes the CHED PSGs in BSEd.
Results and Discussion of Financial Literacy under Teacher Education Program Outcomes	There is a need to include in the discussion the need for mathematics teachers to have strong pedagogical content knowledge (PCK) and depth and breadth of knowledge in mathematics content.	The researcher added the suggestion in the discussion of the results in the first paragraph on page 48.
Results and Discussion on Risk and Rewards	Risk and rewards could be integrated in Statistics (Prediction, Forecast) and Probability through contextualization of problems related to risk and rewards – investment through insurance, stocks, etc. luck on lottery)	The researcher added the suggestion in the discussion of the results in the first paragraph on page 57.
Table 4.3	As research studies have revealed, creativity is a construct of mathematical thinking and every mathematical task will entail a kind of creative thinking, only differing in levels. I suppose that in almost all performance indicators, there is an element of creative thinking but not that explicit for clear categorization in the cells. Moreso, there is the interdependence between and among four competencies in creative thinking domain. The 0 total in many of the rows may not really be authentic numeric considering how creative thinking is operationalized. In creative thinking as stated earlier, there is iteration and this sub process cannot even be captured. Hence, a need to define some limitations in Table 4.3 figures and maybe certain assumptions.	The researcher remapped two performance indicators to be a venue for the generation of diverse ideas that Reviewer 3 suggested and these are those that demand illustrations of mathematical concepts. The act of providing illustrations may demand for either written or visual creative expressions. However, those performance indicators that Reviewer 3 suggested to be aligned with creative thinking, which the reviewer also admits as not explicit in developing creative thinking were not considered in the remapping. Performance indicators like those that begin with "explain" "use", "utilize", which PISA creative thinking framework clarifies as not necessarily what creative thinking means were not considered in the revision of the analysis presented in Table 4.3.
Results and Discussion presented in Table 4.4	Good! But there are other courses too. However, the course description does not reflect the way Plane and Solid Geometry was defined. Say, Logic and Set Theory is high on developing creative thinking. The course is a study of mathematical logic which covers topics such as propositions, logical operators, rules of replacement, rules of inference, algebra of logic and	To be consistent with her analysis in the mapping of the mathematics courses vis-à-vis creative thinking framework, the researcher did not count the course Logic and Set Theory as the course description does not explicitly state the need for creative expression whether in written or visual form. Reviewer 3

	quantifiers. It also includes a discussion of elementary theory of sets such as fundamental concepts of sets, set theorems and set operations.	also acknowledged that the course description does not explicitly reflect the call for creative thinking, although the nature of the course is high on creative thinking.
Results and Discussion for Scientific Problem Solving	I agree – very good envisioning on how these courses can be translated to these actions. However, are these being done the way we ideally look at how courses should be taught this manner?	The researcher put in the recommended revisions of some course descriptions the need to develop would-be teachers' scientific problem solving.
Table 5	Insert "statement" in no explicit targeting. This becomes " no explicit statement targeting…"	The researcher reflected the suggestion of Reviewer 3 in Table 5.
Table 5.3 Program Outcome # 6	Insert… and application of mathematics on financial planning, management and decision making. red marked line can be deleted in- Manifest discretion when selecting approaches or methods that would be effective in teaching mathematics and financial concepts and processes applied in different contexts	The researcher accepted the suggestion of the Reviewer 3 with some modifications as shown in Table 5.
	Since emphasis on collaborative and social learning are very much wanting in the articulation of program outcomes (general teacher education discipline-specific levels) why not include here: Utilize a variety of both student-centered and collaborative social learning approaches and methods in the classroom. You have mentioned that teaching/learning approaches are more individualistic.	The researcher adopted the suggested revision in the performance indicator in the BSEd Mathematics given by Reviewer 3.
	Replace the highlighted in: Develop and use materials that guide the students in using a mathematical software for discovering and learning mathematical concepts and processes (including software for computer simulation) Into… for discovering, learning, applying and interpreting mathematical concepts and processes	The researcher adopted the suggested revision in the performance indicator in the BSEd Mathematics given by Reviewer 3.
Table 5.3 Program Outcome # 7	Maybe a time now to reword "moment of enlightenment".	The researcher revised the program outcome in the BSEd Mathematics as suggested by Reviewer 3.
Table 5.4 on the suggested improvement in the course description of Mathematics in the Modern World	Indicate the specific contexts targeted in mathematics.	The researcher revised the course description of Mathematics in the Modern World as suggested by Reviewer 3.
Table 5.4 on the suggested improvement in the course description of History of Math	If you look into the content of History of Mathematics, more appropriate to this course is the development of creative thinking than financial literacy. Mathematics as a field developed through centuries because of man's ingenuity and creative thoughts, ideas and creative mind. ….mathematical and creative thinking.	The researcher revised the course description of History of Math as suggested by Reviewer 3.
Table 5.4 on the suggested improvement in the course description of College and Advanced Algebra	For the last part of the description: …and practical application of Algebra to matters related to finance, insurance, predicting risk and benefits on health and finance, growth and decay, among others. NOTE; There are universities that have specific courses on Algebra on Finance and Investment	The researcher revised the course description of College and Advanced Algebra as suggested by Reviewer 3.
Table 5.4 on the suggested improvement in the course description of Logic and Set Theory	It may not only be reasoning per se, but students' confidence and ability to articulate or communicate his reasoning Add on….. and how these concepts are applied to social and scientific contexts.	The researcher revised the course description of Logic and Set Theory as suggested by Reviewer 3.
Table 5.4 on the suggested improvement in the course description of Elementary Statistics and Probability	Include: … and pandemic problems Insert: With SPSS and other software, the course expects students to demonstrate with confidence and ease, to solve problems individually …….. Add: Interpretation, drawing of conclusion and decision making	The researcher revised the course description of Elementary Statistics and Probability as suggested by Reviewer 3.
Table 5.4 on the suggested improvement in the course description of Advanced Statistics	Replace evaluation by interpretation and drawing conclusion	The researcher revised the course description of Advanced Statistics as suggested by Reviewer 3.

Table 5.4 on the suggested improvement in the course description of Principles and Strategies in Teaching Mathematics	Can be restated: The students work individually or in teams in designing,……	The researcher revised the course description of Principles and Strategies in Teaching Mathematics as suggested by Reviewer 3.
Recommendations	How about recommendation on revisiting of teacher education program and BSEd-mathematics curriculum framework before making recommendations 1-6 . Moreso, the basis for acceptance of the recommendations on change/improvement of course descriptions of the 20 Mathematics courses in BSEd will be based on the overall curriculum framework. Ideally (and theoretically) these recommendations (to include the recommendations on revision of course description) can be acted upon if creativity, collaboration, problem solving are within the realm of the general, teacher education, and BSEd Program and Curriculum Framework, Hence, revisiting of existing frameworks (GP, TEP, BSEd) is likewise recommended to look into their relevance vis-à-vis the recent demands and challenges in the current world order that entails radical change on the present education curriculum across levels.	The researcher prepared a recommendation following the suggestion of Reviewer 3.