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Mathematics Education 4.0: Teachers` Competence and Skills` Readiness in Facing the Impact of Industry 4.0 on Education

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ABSTRACT

This sequential exploratory study describes the mathematics teachers` competence and skills readiness towards Education 4.0 which is the reflection of Fourth Industrial Revolution on education. Furthermore, it also investigates the relationship of teachers` competence and skills readiness towards education 4.0. For qualitative phase, five (5) experts shared their insights and perspectives about how they view the competence and skills readiness of mathematics teachers towards education 4.0. For quantitative phase, data were obtained from a sample of 500 mathematics teachers from selected Elementary Schools; Junior and Senior High Schools; and State Universities and Colleges (SUCs) from Central Luzon, Philippines during the second semester of S.Y. 2019-2020. Qualitative results revealed that the competence of teachers in Mathematics Education 4.0 (4ME) can be classified according to their technological-pedagogical-content competence related to TPACK framework developed by previous authors. Skills readiness were categorized as technological and digital skills; professional skills; and lifelong learning and personal skills readiness. Quantitative findings showed that mathematics teachers have low levels of competence towards education 4.0 in terms of technological-pedagogical competence which is their ability to integrate advanced technologies in their mathematics instruction and employ new strategies relevant to the needs of Education 4.0.This was assessed though the instrument called Technological-Pedagogical-Content Competence (TPACC) Scale developed through qualitative data analysis and existing related literature and studies. Similarly, mathematics teachers have low level of skills readiness on advanced technologies such as robotics, artificial intelligence, interactive system, virtual and augmented realities, and learning management system. Further, significant relationship exists between teachers` competence and skills readiness towards Mathematics Education 4.0. Lastly, teachers` viewpoints about their suggestions and recommendations in enhancing their competence and skills readiness were enhancement of educational facilities via procurement of ICT equipment and building infrastructure and conduct of more trainings, seminars, and workshops relevant to Education 4.0.

Key words: *Competence, Skills Readiness, Mathematics Education 4.0, Industry 4.0*

II. INTRODUCTION

People stand on the border of a technological revolution that will basically affects the way they live, work, and relate to others. The transformation will be different from the experience of other people in the past in terms of its complexity, scale, and scope. According to the study of Yunos and Din (2019) people do not yet have the knowledge to expand it. However, it was emphasized that the answer to it must be comprehensive and incorporated. Stakeholders from private and public institutions to civil organization must be included. This revolution will greatly affect he education and in particular the mathematics education.

Mathematics was always studied technological and scientific advances. When deciding which actions have allowed for the advances, mathematical tools were observed to be behind almost all specifically from optimizing a device and streamlining the energy cost. This is why mathematics is the highway of the next

industrial revolution, the so-called Industry 4.0 or Fourth Industrial Revolution Era (FIRe). According to Schwab (2016) it is the stage where advanced technology will be used in the development of knowledge and skills. 4 In this era, we will be able to face and experience the birth of Artificial Intelligence (AI), automation, ubiquitous, mobile supercomputing, intelligent robots, self-driving cars, Neuro-technological brain enhancements, and Genetic editing. Virtual and augmented reality, digital twins, and machine learning are other technological developments have their foundation in mathematics. Further, the Industrial Revolution 4.0, according to Ramli (2016) statement refers to smart-factories where machines are connected via web access to a system that reflect the whole production chain and make automated decisions.

It is expected that things have become more complex in this era of industrial revolution. Nowadays, getting an information is very easy because there are a lot of means and ways to get the news. The appearance of 5 Generation Z students with advanced intelligence and digital ability has poses numerous difficulties to instructors (Shahroom & Hussin, 2018). Further, the rise of this fourth Industrial Revolution (IR 4.0) is expected to change the landscape of educational innovation. It was proven in the past that the rising of education from 1.0 to 4.0 is similar to the rising of industry from 1.0 to 4.0 that is why industry is associated with education. In the article of Martin (2018) about the Fourth Industrial Revolution and Education, he discussed that the digital physical structure which combine people and machine and the artificial intelligence controlled the IR 4.0. Education 4.0 corresponds to Science Education 4.0 and Mathematics Education 4.0 in which the competencies that the students will learn in class should match the competencies needed for the industry 4.0. Education 4.0 corresponds to Industry 4.0 on education. It is an educational reform align to the demands and challenges brought about by Industry 4.0, especially workforce demand of it (Anggraeni, 2018; Hariharasudan & Kot,; Hussin, 2018). Educators should be committed in of present and future generations to thrive. From this reason, having an education that does not depends on technology or machine but rather an education that improves the ability of individuals is very essential. A transformation is needed in an education system that is intended for an industrial economy. A system where the application of critical thinking, ability to solve problem, and work with others are needed rather than a system that is only based on process and gathered data and information. An education system that will be transformed in order to meet the needs and demands of the industry.

With the existence of advance technology and procedures in the acquisition of knowledge, Industry 4.0 will be challenging nowadays in the education system (Maria et al, 2018). According to Martin (2018), bringing individuals that are knowledgeable with the use of technology, specifically the proper usage of it is the objective of education. That is why a globalized setting where advanced technology can be used appropriately in giving quality education to students is needed. Students must know the strategy on how they learn effectively, even the ways on how to improve their competency when acquiring knowledge in mathematics.

The acquisition of knowledge is now advanced, patterned and fit to what is needed, flexible, intelligent, and globalized due to the focus of Mathematics education 4.0 in improving the knowledge and skills of the learners. The traditional movement of teaching and learning process was changed in a digital teaching where technology can be used in giving information to students due to the existence of advanced knowledge and skills such as huge information, classified computing and portable design, online networking, Artificial Intelligence (AI), Internet of Things (IoT), Virtual Reality (VR) and Augmented Reality (AR).

The education system, educators, and students work best when they have an advanced educational facility. Wallner, Thomas, and Wagner (2016) in their study about Academic Education 4.0 stated that in higher education institution the facilities in education 4.0 must be based on what is needed by the industry 4.0. Individuals who can follow and work in the globalized world are brought by Education 4.0 facility. This is the facility where the use of technologies such as automation, Iot, digitalization, and teleconferencing to name few are permitted. The learning environment and the education facility are the main source of acquisition of knowledge because the teacher's role nowadays is to facilitate learning. As an association or substitute for teacher, robotics can

act as a facilitator of learning 14 (Messias et al., 2018). Opportunities to examine and practice using technology in education were given to students in other nations because their education system is advanced and digitalized. The learners are the focus and concern in a facility of education 4.0. The experienced that the learners may have is their priority. It must be connected, demonstrated, focused, and led by the learner. If flipped classroom and online learning will be applied (Pangandaman et al., 2018). As can be reflected, things have become now more complex as time changed. In the study of Martin, Bohuslava and Igor, (2018), due to the rapid revolution, the education system must be rooted with the industry 4.0 16. Based on the aforementioned literature and studies about what was expected to teachers in the era of the said industrial revolution, can we say that they are ready and competent to face this change in our society? Can we adapt on the new era of revolution`s needs? This study primarily aims to describe and analyze the status our educators in higher education in transforming mathematics education to mathematics education 4.0 in terms of their level of readiness and competence in facing the new shade of revolution. Readiness and competence are the two vital constructs in this study. Readiness in the educational context has something to do with teachers' awareness, knowledge of utilization, perceptions, and attitudes toward their capabilities and skills for technology integration as well as gaining experience in the use of educational technology (Msila, 2015). On the other hand, 'competence' has obtained a growing reputation in diverse academic disciplines, and now much supported in universities aiming at producing competent and prepared graduates for the job (Lester, 2014; O'reilly et al., 2013). Competence is about teachers` ability. Competence is what they can do if they could do it. It is knowledge put into action by the teacher in his teaching pedagogy and utilization of different technologies in the classroom. Furthermore, this study also provides brief views coming from experts on how mathematics teachers will take the challenge to see for themselves if they are competent and ready enough to face this new trend in education. This study will assess their existing level of readiness and competence towards their new mission on mathematics education 4.0.

Objectives

The general aim of this study is (1) to determine the views of experts on their perspectives about teachers` competence and readiness towards mathematics education 4.0; to determine mathematics teachers` level of technological, pedagogical, and content competence needed for the new revolution in education; (3) to determine the level of mathematics teachers` skills readiness in facing the impact of Industry 4.0 on education; (4) to determine the significant relationship between mathematics teachers` competencies and readiness skills towards mathematics education 4.0 (5) to determine the viewpoints of the teachers about their recommendations to further improve their competence and readiness to face the impact of Fourth Industrial Revolution Era (FIRE) to Mathematics education.

Conceptual Framework

The study is mainly anchored in Khale`s Social Adaptation Theory which states that people's cognitive life facilitates their functioning in their social environments. This theory states that due to the continuous adaptation through awareness and internal arrangement of data the schemata are developed. Adaptation is what activate change rather than reasoning. According to Terziev (2019), social adaptation is the process of establishing compliance on requirements brought about by change. This process has many methods that may be applied to achieve compliance which includes communication, acquisition of knowledge, adjustment, inclusion, and others. There is no specific method that must be used in adapting in social environment but teachers should be flexible enough to adjust or to adapt in the new system especially in educative system.

Moreover, according to Bandura (1977) as cited in the study of Zhang (2018) described social adaptation could be considered as the process in which students learn how to act in a way suited to a new environment. In other areas Neo-Piagetian concepts was applied in social adaptation theory due to the change in attitude and the effectiveness of advertising. This theory is related in the study since it has something to do with the adjustments of the teachers in facing the new trend in mathematics education

primarily because of the rise of Fourth Industrial Revolution 4.0. Figure 1 below presents the paradigm of the study.

Figure 1. Sequential Exploratory Mixed Method Framework

In an exploratory design, qualitative data is first collected and analyzed, and themes are used to drive the development of a quantitative instrument to further explore the research problem (Creswell and Plano Clark 2011; Teddlie and Tashakkori 2008; Onwuegbuzie, Bustamante, and Nelson 2010). As a result of this design, three stages of analyses are conducted: after the primary qualitative phase, after the secondary quantitative phase, and at the integration phase that connects the two strands of data and extends the initial qualitative exploratory findings (Creswell and Plano Clark 2011).

III. Methods

Research Design

This study employed the mixed methods approach through exploratory design. In mixed method studies, it is the best design that a researcher has choose since it is a complete package, a combination of a qualitative and quantitative approaches, which serve as a hybrid design.

As cited in the study of Berman (2017). Exploratory is a two way design the first stage is qualitative data collected and analyzed, and themes or categories are employed to engage the development of quantitative instrument to further explore the research problem. As result of this design, three stages of analyses are conducted: after the primary qualitative phase, after the secondary phase quantitative phase, and the integration phase that connects the two strands of data and extends the initial qualitative exploratory findings. (Creswell & Plano Clark, 2011).

Participants

The respondents of the study were 500 mathematics educators selected from different State Universities and Colleges (SUCs) in Region III and Schools from Division of Pampanga during S.Y. 2020-2021. Purposive sampling was employed to select the key informants of the study based on certain criteria such as job position and length of service. Five (5) selected teachers who are at least assistant professors or master teachers and rendered service for at least 5 years were interviewed.

Research Instruments

a) Technological, Pedagogical, and Content Competence towards Mathematics Education 4.0 (TPACCME-4) Scale

The instrument was developed through result of interviews from the participants in which their responses about teachers` competence were all focusing on technological, pedagogical, and content competence. The researcher also considered the TPACK Instrument developed and validated by Schmidt, Baran, Thompson, Koehler, Mishra, and Shin as basis for crafting the TPACC instrument. Six components of competence of teachers towards mathematics education 4.0 were included in the questionnaire measuring their technological, pedagogical, content, technological-content, pedagogical-content, and technological-pedagogical-content competence. Items were rated by the respondents from 1 (Strongly Disagree) to 4 (Strongly Agree). The scale passed the confirmatory factorial analysis (CFA) considering its item loadings, content validity index (CVI) of 100% and reliability coefficient of 0.97.

b) Readiness Skills towards Mathematics Education 4.0 (RSME 4) Scale

It is a questionnaire which evaluates the levels of readiness of teachers in facing the impact of

Industry 4.0 to mathematics education. The scale has 3 components of skills readiness namely technological and digital skills readiness, professional skills readiness, and lifelong learning and personal skills readiness. Items were also rated by the respondents from 1 (Strongly Disagree) to 4 (Strongly Agree). The scale passed the confirmatory factorial analysis (CFA) considering its item loadings. Moreover, the instrument possessed an excellent content validity index (CVI) since 5 out of 5 raters assessed the instrument to be highly relevant and it reached the desired internal consistency of 0.98.

Regarding the confirmatory factor analysis part of the study, both scales can be said to be successfully cross-validated. First, all the fit indices recommended to be examined in this type of research indicate a good fit between the measurement model tested and the data. Second, while statistically inadmissible parameter estimates (such as negative variances) are not uncommon in confirmatory factor analytic studies (Bollen, 1989), all of the estimates in the present study were statistically admissible and in the expected direction. Third, the factor structure and the factor loadings obtained in a previous exploratory factor analysis with the same scale and items (Ozturk, 2010) showed resemblance to those obtained in the present confirmatory factor analysis, exhibiting consistency across the two studies, hence, providing additional evidence for cross-validation of the scales. For validity, the items were rated by five (5) experts and all of them rated the items from relevant to highly relevant. As for the reliability coefficients, all of the items were significantly higher than the commonly used acceptability threshold of .70.

c) Semi-Structured In-depth Interview

The researcher conducted a semi-structured in-dept interview in order to obtain qualitative data for the study. A semi-structured in-depth interview is usually one in which the interviewer has a checklist of topic areas or questions. The intention is to get the informants to talk in their own terms, hence questions tend not to be too specific allowing for a range of possible responses. For teachers` competence, the interviews consisted of a series of open and closed questions related to six themes for competence such as technological, pedagogical, content, technological-content, pedagogical-content, and technological-pedagogical-content. A general interview guide (Patton, 2002) was used in order to keep 'the interactions focused while allowing individual perspectives and experiences to emerge' (p. 334). Such an approach provided scope for exploration of the ways in which individual teachers stated some indicators to be considered under the themes illustrated.

d) Open-ended Questionnaires

The open-ended questionnaire was developed thru different relevant literature and result of interviews from experts. The questions focused on viewpoints of the teachers on their skills readiness needed in facing the impact of 4IR in mathematics education 4.0 including their recommendations and possible solutions to meet the standards needed in mathematics education 4.0. Follow-up interviews were conducted to augment the data gathered through the open-ended questionnaires. Galang (2014) as cited in the study of Quizon, Nicdao, & Nicdao (2020) follow-up interviews are necessary to "supplement the data provided through the open-ended questionnaires and to obtain explanation on responses which needed further clarification.

2.4. Procedure

The researcher used two questionnaires in gathering first-hand information from the respondents. Before the copies of the questionnaires were distributed to the respondents, the researcher sought first the permission of the School Superintendent of the Division of Pampanga and SUC Presidents from different universities through pre-survey letter reflecting the purpose of the study. After granted permission from the said administrators, the researcher secured a Notice of Non-disclosure agreement and Data Privacy Notice. The respondents were given the freedom to stop participating if they have personal reasons and they need not worry about the consequences of their decision. Furthermore, the instructions were given to the respondents in answering the questionnaires and the time it would take them to finish answering. After all of these ethical procedures in research, the researcher conducted semi structured interviews via Google Meet to

gather qualitative data. The developed instruments through qualitative results were also administered via google forms. The researcher used coding in evaluating the qualitative responses. Coding was used to apply key terms. According to Gibbs and Taylor (2010) as cited in the study of Quizon, Nicdao, & Nicdao (2020), coding involves going through the data for themes, ideas and categories and then marking similar passages of text with a code label so that they can easily be retrieved at a later stage for comparison and analysis. Codes with similarities were organized and grouped into concepts since they share certain qualities that denote a pattern and finally, themes were developed from related concepts. Quantitative data gathered were tallied, tabulated, processed and treated using Statistical Package for Social Sciences (SPSS). Weighted mean and standard deviation were the statistical tools used UN describing the competences and skills readiness of teachers in facing mathematics education 4.0.

IV. Results and Discussions

Qualitative Data

Competence of Teachers in Facing the Impact of Industry 4.0 on Mathematics Education 4.0

The interview with five faculty experts revealed various insights about competence expected from teachers in Mathematics Education 4.0 (4ME). Responses of the participants were focused on technological, pedagogical, and content competencies of mathematics instructors which will be their characteristics for the revolution in education. These three components are consistent with three kinds of knowledge stated by Thompson and Mishra (2008) which are technology, pedagogy, and content. After thorough analysis through coding of key terms and categorization of codes with similar concepts, the researcher found out the components of competence of teachers are also similar to the components of knowledge introduced by Punya Mishra and Matthew Koehler in 2006 which is the TPACK. It is a technology integration framework that identifies three types of knowledge instructors need to combine for successful educational technology integration—technological, pedagogical, and content knowledge. With these, the researcher aligned the themes of expected competence of teachers for Math Education 4.0 on the framework of Mishra and Koehler which is more on competence based. The themes emerged were technological competence, pedagogical competence, content competence, technological-content competence, pedagogical-content-competence, technological-pedagogical competence and technological-pedagogical-content competence of mathematics teachers in addressing the needs of Industry 4.0.

Figure 2 illustrates the framework which arose in the findings of the study. This framework was derived from the TPACK Framework of Mishra and Koehler (2006). As can be gleaned on the framework, the researcher focused on the competence of teachers in which competence as defined is knowledge put into action or practice.

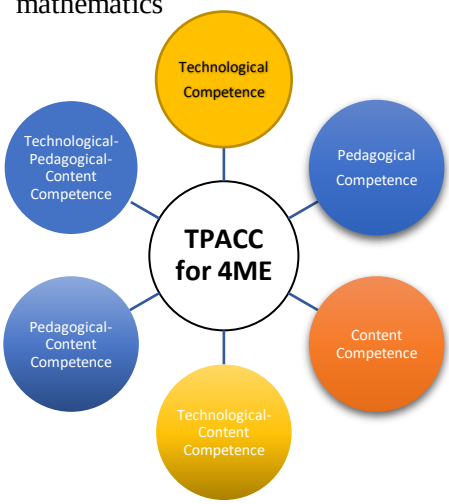

Figure 2. Technological, Pedagogical, and Content Competence (TPACC) Framework in Mathematics Education 4.0

The operational definition of different teachers` competence under Mathematics Education 4.0 with the transcripts of responses from experts are shown below which supported the development of the proposed framework:

Technological Competence. The first competence domain of teachers in Mathematics Education 4.0 which refers to the ability of to use various educational technologies**.**

"Teachers in Mathematics Education 4.0 should be able to use various technologies in teaching. They should be competent on different technological and digital tools. They should possess mastery on utilizing and employing educational technologies in teaching mathematics." (E1)

"A Math Education 4.0 instructor should be flexible enough to adapt in the newest trends on technological advances. He or she should be competent in technology-based instruction" (E2)

"Mathematics Teachers under Education 4.0 can be described to be competent in terms of using technology not only in instruction but also using technology in performing mathematical calculations/computations so that they can share it also to their students." (E3)

"Teachers should be both knowledgeable and competent when it comes to educational technologies used in mathematics instruction" They should have the technical know-how when it comes to technologies." (E4)

"Math 4.0 Teachers for me should be adaptable to the newest trends on technologies. They can set up educational technologies in the classroom on their own and download, upload, install software on their laptops/desktops. They should be updated on the newest technological advances that they can use in their instruction." (E5)

As can be observed on the responses of participants on their views about technological competence expected from teachers under mathematics education 4.0. In general, they articulated that teachers should be competent on different technological and digital tools and their uses in the teaching and learning process. They should be updated in the newest technological advances in education and flexible enough to adapt on these trends. As stated in the study of Burroughs (2017), teachers are always expected to stay relevant to current teaching technologies. King and Cox (2011) articulated that higher education institutions cannot ignore technology hence administrators, teachers, and students should embrace its impact on education.

Pedagogical Competence. The second competence domain of teachers in Mathematics Education 4.0. This focuses on the ability of teachers to use different strategies, methods, and techniques in teaching which includes classroom management, assessment, lesson plan development, and student learning.

"Teachers in Mathematics Education 4.0 should be flexible in doing their lesson plans which is aligned in the approved curriculum pertaining to Education 4.0." E1

"A Math Education 4.0 instructor should have various ways of assessing their students` performance. They should be competent when it comes to employing different teaching strategies like blended learning, hybrid learning, flipped classroom, flexible learning. Further, they should be excellent in using personalized learning strategies like differentiated instruction in the classroom since there are different types of learners in the classroom" (E2)

"Mathematics Teachers under Education 4.0 can be described to be competent in employing different classroom strategies, maintaining classroom management and using different modes of assessment" Teachers should value the importance of collaboration and cooperation among students when solving problems or performing tasks. (E3)

"Teachers should be competent in preparing lessons addressing the different needs of their diverse learners. They should be equipped with technical skills in using newest strategies and technological skills used in teaching. (E4)

"Math 4.0 Teachers for me should be adaptable to the newest trends on teaching strategies used for this revolution in education which will boost the critical thinking skills of the students They should possess mastery in using different assessment strategies such as performance based assessment, project based, and product based assessment" (E5)

As reflected on the responses of the experts, it showed that mathematics teachers are facing more challenging roles in Education 4.0. They must know how to act as a class mediator, how to create a positive, supportive and safe learning environment for all students, how to set long-term and short-term goals, how to encourage students' curiosity, how to communicate effectively, how to use technology (Xing, 2015), how to prepare specialized and trained professionals to work in a global and digital environment. Further, Harkins (2008) stated in his study that recalibration of strategies in new mode of education is really indispensable.

Content Competence. The third competence domain which refers to the ability of teachers to become content-experts or subject specialist of different fields of mathematics.

"Teachers in Mathematics Education 4.0 should be competent when it comes to mastery of the subject matter they teach. They should be competent in their field of specialization" E1

"A Math Education 4.0 instructor should have mastery of the subject matter. They should have sufficient competencies in understanding the learning competencies that they will teach" (E2)

"Mathematics Teachers under Education 4.0 should not only focus on the theories, axioms, postulates in mathematics but also they know for themselves the application of such theories". (E3)

"Teachers should have sufficient knowledge on their field of specialization. They should be capable of doing research which will add up on their prior knowledge. (E4)

"Math 4.0 Teachers for me should be competent and credible on the contents of the mathematics subject they teach. They should be content expert" (E5)

As viewed on the responses of experts, majority of them stated that mastery of the subject matter really matters in Education 4.0. According to Kamamia, Ngugi, and Thinguri (2014), mastery of the subject matter not only influences teacher's competency to teach but also the way they assess students` performance. Correction of learners' tests and assignments depends on teacher's mastery of the subject matter.

Technological-Content Competence. The fourth competence domain which refers to teachers' ability to utilize different educational technologies that can change the way learners understand and practice concepts in a specific content area.

"Teachers in Mathematics Education 4.0 should be competent in using technologies such as application tools and software to connect and discover new contents in their field. They can create engaging and interactive presentations and videos about the topic and they can record and edit audio and video clips for their math lessons" E1

"A Math Education 4.0 instructor has competencies on downloading online instructional materials relevant to their subject. They can access e-journals and other contents that can be found on websites" (E2)

"Teachers have competencies in using MS PowerPoint, Google Slides, Canva, Prezi, and other applications for their lesson. They can provide digital or e-copies of their lesson. (E4)

The intersection between technological and content competence of the teachers in Education 4.0 is illustrated on the responses of the experts. As articulated by the experts, teachers should have competencies in all technological and digital tools used in upgrading their content competencies. Instructors need to relearn and equip themselves with the digital tools to meet the learning preference of the Gen Z students. As stated in the study of Hussin (2018), there are many digital tools available online that instructors can choose from. Educational Technology and Mobile Learning (2016) website suggested instructors to equip themselves with these nine fundamental digital skills such as recording and editing audio clips, create annotated, interactive, and engaging video contents, create visually engaging contents, use social networking websites, use of blogs and wikis, use of social bookmarking websites, create engaging presentations, create digital portfolios, and create non-traditional quizzes.

Pedagogical-Content Competence

The fifth competence domain which refers to the content competencies that deals with the

teaching process.

"Teachers in Mathematics Education 4.0 should be competent in selecting effective teaching approaches and strategies to guide students` thinking and learning mathematics" E1

"A Math Education 4.0 instructor has the ability to teach the required learning math competencies to the students" (E2)

"Mathematics Teachers under Education 4.0The role of teacher gains importance gradually in Education 4.0 because teacher is in mentor role now. Teacher needs to have self-improvement skills to guide students for dealing with big data and digital environment, learning how to learn and taking precautions for cyber-security (E3)

"Teachers can play the role of a mentor, coach, counselor in dealing with students with marginalized performance in mathematics. (E4)

"Math 4.0 Teachers should be excellent when it comes to aligning the appropriate strategy for every lesson in math. They must organize their lessons for smooth transfer of learning" (E5)

As articulated by the faculty experts, pedagogical-content competence focuses more on the ability of teachers to select effective strategies appropriate to the learning competencies to be acquired by the students. Alignment of teaching strategy to content is vital for the smooth delivery of instruction and attain desirable students` performance outcomes. Guidance, mentoring, and coaching competencies of teachers are also important. Kilic (2018) emphasized that mentor teacher figure will be important instead of the classical authoritarian teacher figure in Mathematics Education 4.0. The main reason why teachers' guidance skills gain importance is that the amount information which students can access is plenty. So, it is stated that the teachers of Mathematics Education 4.0 should be a guide for students to access and benefit from this new information rather than being a subject matter specialist or content experts (Wallner, & Wagner, 2016, p.157).

Technological-Pedagogical Competence

As can be observed on the responses of the participants, they stated that technological pedagogical competence is more on aligning technology with teachers` pedagogy in a of choosing appropriate technologies which will enhance their teaching. In the article of Renwick (2016), pedagogy is the driver, technology is the accelerator. Focusing on pedagogy, or the craft of teaching, is a frame that helps ensure educators prioritize content, strategies and students in our work. Moreover, education in 4IR teachers` skills and competencies in artificial intelligence, robotics, the Internet of Things, augmented reality, virtual reality, 3D printing, smart factories are needed to align their pedagogy on technological advances (Bezuidenhout, 2018).

Technological-Pedagogical Competence

The sixth and final competence domain, technological pedagogical content competence (TPACK), refers to the teachers` ability to integrate technology into their teaching—the total package. The sixth competence domain refers to teachers' ability to utilize various technologies in enhancing their teaching strategies and processes.

"Teachers in Mathematics Education 4.0 should be competent enough to choose updated technological or digital tools which will serve as aid on their instruction" E1

"A Math Education 4.0 instructor should be able to use various software applications and technological device which will enhance their teaching" (E2)

"Math 4.0 Teachers should be excellent on determining newest trends on technologies used in upgrading their way of teaching. They can use augmented and virtual realities in their class" (E5)

"Teachers in Mathematics Education 4.0 should be competent in employing different types of blended learning such as Flipped Classrooms, Bring your Own Device in teaching mathematics. They can employ new technologies such as smartboards and internet connections in their instruction" (E1)

"Mathematics Teachers under Education 4.0 should be able to employ technology-based instruction in the classroom. They should have the ability to select appropriate technologies suited to their instruction." .(E3)

"Teachers can maximize the use of social networking such as Facebook, Instagram, Twitter in their mathematics instruction. They should be capable of using online assessment tools like Google Forms, Kahoots, Mentimeters, Quizziz, etc in assessing students` performance. (E4)

"Math 4.0 Teachers should be excellent when it comes to facilitating effective online and interactive math discussions. They can use mathematics applications like Geometer Sketchpad, Geogebra, and Grapes System" (E5)

As viewed on the experts` responses on technological-pedagogical competences of teachers under mathematics education 4.0, they stated that teachers should be able to use appropriate technologies in their instruction. Teachers should be competent in maximizing the use of technology in enhancing and aiding their teaching strategies. Assessment software applications and math teaching application tools were also mentioned. The use of social media and online assessment tools were also articulated. Augmented and virtual realities were also mentioned as can be expected in the new dace of education under Industry 4.0. The findings found in this study is in line with a study conducted by Halili (2019). The author stated that learners get to explore more knowledge and information rather than just depending on the textbook content. The author further explained this is evident when the virtual reality and augmented reality were being in practice into the real-life that has increased the interest amongst the students as the technological advancements provide a vision of the real-world setting. Adding on, students are exposed to more hands-on activities in a technology-based course that will cultivate their understanding and knowledge about the subject, whereas the teachers get a chance to design their lesson plans in a more effective and interesting manner that gives a huge positive impact on a student's active learning (Finger & Trinidad, 2002; Jorge et al., 2003; Young, 2003;

Jamieson-Procter et al., 2013).

Skills Readiness of Teachers in Facing the Impact of Industry 4.0 on Mathematics Education 4.0

The interview with five experts uncovered insights on skills readiness of mathematics educators in the era of Fourth Industrial Revolution. Qualitative analysis used in determining the themes for teachers` competence in Mathematics Education 4.0 was also employed in determining the theme categories for teachers` skills readiness. Themes arose on the result of interviews were technological and digital skills readiness, professional skills readiness, and lifelong learning and personal skills readiness. This was presented through a framework illustrated in Figure 3.

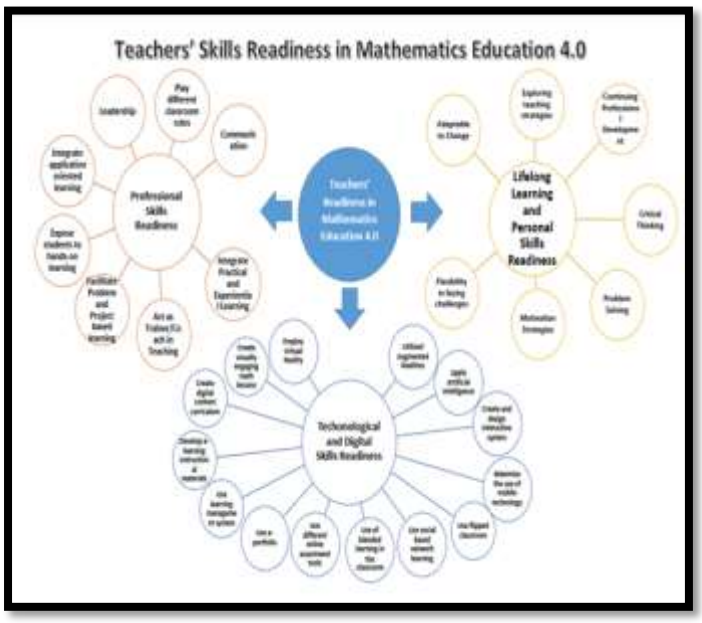

Figure 3. Skills Readiness of Teachers in Mathematics Education 4.0

When the findings were examined in Figure 3, it was inferred that the skills readiness of mathematics teachers needed in Education 4.0 were grouped according to the technological and digital skills readiness; professional skills readiness; and lifelong learning skills readiness. Technological and digital skills readiness of teachers as result of interviews were the readiness of teachers in utilizing augmented realities, applying artificial intelligence, creating and designing interactive system, maximizing the use of mobile technology, using flipped classroom, using social network based learning, employing blended learning, using online assessment tools, using e-portfolio, using learning management system, developing e-learning instructional material, creating digital content curriculum, creating visually engaging math lessons, and employing virtual realities. Technological and digital skills readiness as defined by Spector (2012) as cited in the study of Christensen and Knezek (2013) involves more than just technology literacy skills. It involves the ability to choose the appropriate tools for the task at hand in order to be productive citizens. ... These include digital literacy, information literacy, visual literacy, and technology literacy. Every teacher needs to be more responsible in producing quality graduates for this industrial. According to research conducted by Technology and Mobile Learning (2016), students nowadays should be exposed to different technology and digital skills. Fisk (2017) explains that the new vision of learning is aimed highly to improve the digital technologies competences across all levels to enhance the use of technology in teaching and active learning.

The professional skills readiness of mathematics teachers under Education 4.0 as viewed by the experts were the readiness of teachers in playing different classroom roles, showing good communication, integrating practical and experiential learning, acting as a coach/training in teaching, facilitating project and problem-based learning, exposing students to hands-on learning, integrating application-orient learning, and possessing good leadership in the classroom. For teachers` lifelong learning and personal skills readiness, experts articulated that they should be characterized as ready to be adaptable to change, ready to explore new teaching strategies, ready to continue professional and personal development, ready to be a critical thinker and problem solver, ready to be flexible in facing challenges, and ready to employ motivation strategies in the classroom.

Transcribed responses of experts were shown below. The first skills readiness is the technological and digital skills readiness.

Technological and Digital Skills Readiness

"Teachers in Mathematics Education 4.0 should be ready and prepared to use different technological and digital tools in teaching. They should be ready in using ICT, social networking such as Facebook, Instagram, Twitter, etc in teaching mathematics. They can also maximize the use of mobile technology in teaching the subject" (E1)

"A Math Education 4.0 instructor should be ready to develop and use e-learning materials such as e-journals and e-portfolio in their instruction. They should be prepared in transforming traditional math classroom to a learning environment with visual and augmented realities. They should be ready to face the challenge of Education 4.0 wherein artificial intelligence and robotics will be needed in the instruction." (E2)

"Mathematics Teachers under Education 4.0 can be described to be ready in employing various technological tools and software in the classroom like showing engaging and interactive video lessons in the classroom. They should be equipped with knowledge and competence on using online learning materials, online assessment tools, and different online platforms" (E3)

"Teachers should be ready to face the challenges brought about by Industry 4.0. Technological and digital skills are needed and expected from a teacher teaching in this era of education. Using flipped classrooms, different forms of blended learning, online learning, etc..". (E4)

"Math 4.0 Teachers for me should be ready to be both expert on technological and digital tools used in the classroom. Creating digital materials for the students in which they can just

download it via internet. Teachers should be ready to new technological advancements in education." (E5)

Professional Skills Readiness

"Teachers in Mathematics Education 4.0 should be ready and prepared to be flexible in playing different roles in the classroom such as facilitator, mentor, coach, trainer, counselor, and adviser of students to develop their skills to the fullest of their potential. They should possess excellent communication and leadership skills in the classroom" (E1)

"A Math Education 4.0 instructor should be ready to employ hands-on learning, student-centered environment, application-oriented learning. They should be more focus on developing the critical and creative thinking skills of the students." (E2)

"Mathematics Teachers under Education 4.0 can be described to be ready to communicate well to the students and possess good leadership skills He or she should act professionally and ethically as a teacher" (E3)

"Teachers should be ready to employ project and product based learning as well as personalized learning in the classroom. They should be ready to play different roles in the classroom.". (E4)

"Math 4.0 Teachers for me should be ready to be a guidance counselor of the class, adviser, mentor, and coach of the students in the learning environment." (E5)

Lifelong Learning and Personal Skills Readiness

"Teachers in Mathematics Education 4.0 should be ready and prepared to be an excellent critical thinker and problem solver. They should be ready to adapt to change in the educative system" (E1)

"A Math Education 4.0 instructor should be ready continue professional development or career by attending seminars, trainings, and workshops in order for them to improve their craft." (E2)

"Mathematics Teachers under Education 4.0 can be described to be ready for being flexible in facing new challenges brought about by Industry 4.0 which will be more on technological advances and upgraded educational facilities." (E3)

"Teachers should be ready to explore new various strategies in teaching mathematics. They should also consider other motivation strategies that can be used in the classroom". (E4)

"Math 4.0 Teachers for me should be ready to be adaptable to change and flexible to all challenges that they may face in the educative process." (E5)

As viewed on the responses of the participants, they really talked about the lifelong learning and personal skills towards Education 4.0. Teachers should be an excellent critical thinker and problem solver in this era or education. They should accept that they should learn to adapt on changes on the educational system. They should begin exploring new instructional strategies which will meet the demands of Education 4.0. They should be patient enough to face all the challenges and ready to continue to strive harder for the sake of their professional growth and development. Himmetoglu and Aydug (2020) found out in their study that the main qualifications expected from the teachers of Education 4.0 are technological skills, guidance skills, lifelong learning skills and personal characteristics.

Quantitative Data

Descriptive Analysis of Mathematics` Teachers` Assessment of their Technological Pedagogical and Content Competence (TPACC)

Tables 1 to 6 presents the teacher-respondents assessment of their technological competence, pedagogical competence, content competence, technological-content competence, pedagogical-content competence, and technological-pedagogical competence needed for Mathematics Education 4.0.

Descriptive Analysis of Mathematics Teachers` Technological Competence

Table 1

Mathematics Teachers` Assessment of their Technological Competence

Statements	**Mean** $(\bar{X})$	**SD** ***(s)***	**Verbal Description**
I can use standard sets of software tools such as word processors, spreadsheets, browsers, and e-mail.	3.07	0.61	Agree
I can set up educational technologies needed for my instruction	3.20	0.63	Agree
I can keep updated with new important trends on technologies.	3.13	0.64	Agree
I can easily adapt with the advancements in technology.	3.20	0.70	Agree
I can install and remove software programs, and create and archive documents.	3.10	0.66	Agree
Grand Mean	**3.14**	**0.65**	**Agree**

Data revealed that the respondents agreed in all indicators of their technological competence in response to the challenge of Education 4.0 such example is using word processors, spreadsheets, browsers, and emails. Moreover, they also agreed that they can set up educational technologies in the classroom, and can install and remove software programs. In general, they achieved an overall weighted mean score of 3.14 with standard deviation of 0.65 which implies that they possessed a high level of technological competence.

Descriptive Analysis of Mathematics Teachers` Pedagogical Competenc

Table 2

Mathematics Teachers` Assessment of their Pedagogical Competence

Statements	**Mean** ($\bar{X}$)	**SD** (*s*)	**Verbal Description**
I can assess students` mathematics performance.	3.31	0.62	Strongly Agree
I can use personalized learning strategy in my math class.	3.27	0.63	Strongly Agree
I can assess student learning in multiple ways.	3.22	0.60	Agree
I can adapt my teaching based upon what students currently understand or do not understand.	3.25	0.63	Agree
I can use a wide range of teaching approaches in a classroom setting.	3.21	0.58	Agree
I can familiarize and solve common student understandings and misconceptions.	3.24	0.60	Agree
I can organize and maintain classroom management my math class	3.30	0.64	Strongly Agree
I can develop the skills of my learners to transform math ideas into practice	3.24	0.61	Agree
I can support the interaction among students and collaborative activity as a means of teaching and learning.	3.30	0.63	Strongly Agree
I can motivate my students to do their best in learning mathematics.	3.35	0.63	Strongly Agree
Grand Mean	**3.27**	**0.62**	**Strongly Agree**

Results showed that the respondents strongly agreed in 5 out of 10 indicators of their pedagogical competence. This implies that they are excellent in terms of assessing students` mathematics performance, using personalized learning strategy, organizing and maintaining classroom management, supporting interaction among students for collaboration, and motivating students to do their best in learning mathematics. Moreover, the respondents agreed in the remaining indicators of pedagogical competence. Overall, the respondents are said to be excellent in their pedagogical competence needed in the revolution of education with grand weighted mean of 3.27 and standard deviation of 0.62. This implies that they possessed a very high level of pedagogical competence needed in Mathematics Education 4.0.

Descriptive Analysis of Mathematics Teachers` Content Competence

Table 3

Mathematics Teachers` Assessment of their Content Competence

Statements	**Mean** ($\bar{X}$)	**SD** (***s***)	**Verbal Description**
I have sufficient knowledge about different fields of mathematics.	3.21	0.57	Agree
I can easily understand the lesson in any field of mathematics	3.07	0.62	Agree
I can be considered as content-expert when it comes to any field of mathematics.	3.22	0.59	Agree
I have mastered the learning competencies in different fields of mathematics.	3.13	0.63	Agree
I can understand the learning competencies in different fields of mathematics.	3.28	0.59	Strongly Agree
Grand Mean	**3.18**	**0.60**	**Agree**

Data showed that the respondents have agreed in 4 out of 5 indicators of their content competence. They strongly agreed that they can understand the learning competencies in different fields of mathematics with computed mean of 3.28 and standard deviation 0.59. Generally, the respondents high level of content-competence needed for Mathematics Education 4.0 having a computed grand mean of 3.18 and standard deviation of 0.60.

Descriptive Analysis of Mathematics Teachers` Technological- Content Competence

Table 4

Mathematics Teachers` Assessment of their Technological-Content Competence

Statements	**Mean** ($\bar{X}$)	**SD** (***s***)	**Verbal Description**
I can browse learning materials through online materials such as e-books and e-journals relevant to my subject.	3.18	0.61	Agree
I can use technologies in performing computations in mathematics.	3.17	0.65	Agree
I can record and edit audio clips using software applications for my mathematics lessons.	2.48	0.69	Disagree
I create annotated, interactive and engaging video math contents	2.44	0.69	Disagree
I can use social networking websites to connect and discover new content in mathematics.	3.07	0.67	Agree

I can create engaging presentations like MS PowerPoint, Google slides, Canva, Prezi, etc.	3.09	0.69	Agree
I can intelligently use the data and information that can be found in e-learning materials.	3.07	0.67	Agree
I can create interactive video contents for my math lesson	2.44	0.66	Agree
I can convert the printed content and activities in the curriculum to the digital.	2.50	0.71	Agree
I can develop electronic learning activities that encourage my students to be critical and creative thinkers.	2.47	0.66	Disagree
Grand Mean	**2.79**	**0.67**	**Agree**

As can be gleaned on the data, result showed that the respondents agreed in 7 out of 10 indicators of their technological-content competence. It is worthy to note that there are 3 out of 10 indicators in which the mathematics teacher-respondents disagreed such as recording and editing audio clips using software applications, creating annotated, interactive, and engaging video math lessons, and develop electronic learning activities that encourage my students to be critical and creative thinkers. This implies that they have low level of competence on these indicators. As a whole, the respondents still have high level of technological-content competence having a computed mean assessment score of 2.79 and standard deviation of 0.67.

Descriptive Analysis of Mathematics Teachers` Pedagogical- Content Competence

Table 5

Mathematics Teachers` Assessment of their Pedagogical -Content Competence

Statements	**Mean** ($\bar{X}$)	**SD** (***s***)	**Verbal Description**
I can select effective teaching approaches to guide student thinking and learning in mathematics	3.21	0.61	Agree
I can effectively teach the required learning competencies for my students.	3.19	0.61	Agree
I can serve as a mentor to my students for their process of learning their lessons in mathematics.	3.33	0.66	Strongly Agree
I can organize and plan ahead of time all the lessons and activities in my math class.	3.29	0.65	Strongly Agree
I can do counseling for my students having difficulty in mathematics.	3.29	0.67	Strongly Agree
Grand Mean	**3.26**	**0.64**	**Strongly Agree**

An overall mean of 3.26 and standard deviation of 0.64 was attained in describing the level of pedagogical-content competence of mathematics teachers. This only shows that the respondents have very high level of pedagogical content competence. Which focuses on their ability to use appropriate strategies or methods of teaching in relation to the topics that they present. On the table, the respondents are said to be excellent when it comes to serving as a mentor of students, organizing lesson plans ahead of time, and doing counseling for students having difficulty in mathematics.

Descriptive Analysis of Mathematics Teachers` Technological-Pedagogical Competence

Table 6

Mathematics Teachers` Assessment of their Technological-Pedagogical Competence

Statements	**Mean** ($\bar{X}$)	**SD** (***s***)	**Verbal Description**
I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches.	3.06	0.64	Agree
I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	3.09	0.67	Agree
I can use augmented realities in teaching mathematics such as Geometer Sketchpad, GeoGebra, and GRAPES (GRAph Presentation & Experiment System), etc..	2.46	0.68	Disagree
I can use blogs and wikis to create participatory spaces for my students in mathematics.	2.21	0.68	Disagree
I can facilitate effective online and interactive mathematics discussions.	2.78	0.65	Agree
I can employ different types of blended learning like Flipped Classroom, Bring Your Own Device (BYOD) in teaching mathematics.	2.30	0.66	Disagree
I can deliver the math curriculum via remote learning or e-learning.	2.65	0.60	Agree
I can maximize the use of social networking (Facebook, Instagram, Twitter, etc	2.73	0.66	Agree
I can use virtual and augmented realities in my math class	2.41	0.65	Disagree

I can facilitate hybrid learning strategy in mathematics.	2.31	0.61	Disagree
I can use robotics in developing the competence of my students in math	1.58	0.62	Strongly Disagree
I can utilize cloud technology in my mathematics instruction.	1.87	0.67	Disagree
Grand Mean	**2.45**	**0.65**	**Disagree**

As reflected on the table, data obviously showed that the majority of the indicators for technological-pedagogical competence of teachers were majority disagreed by the respondents. This only implies that they have low level of technological-pedagogical competence considering the computed overall mean score of 2.57 and standard deviation of 0.65. In particular, the respondents have low level of technological-pedagogical competence in terms of using augmented realities; blogs and wikis; virtual and augmented realities; robotics; and cloud technology. Furthermore, mathematics teachers also have low level of competence in terms of employing different types of blended learning like Flipped Classroom; BYOD; and hybrid learning.

Descriptive Analysis of Mathematics` Teachers` Assessment of their Readiness on Technological and Digital Skills, Professional Skills, and Lifelong and Personal Skills Needed for the Mathematics Education 4.0

The respondents` assessment of their level of their skills readiness for mathematics education 4.0 in terms of technological and digital; professional; and lifelong learning and personal is presented on Tables 7 to 9.

Descriptive Analysis of Mathematics Teachers` Technological and Digital Skills Readiness

Table 7 illustrates the mathematics teachers` assessment of their readiness in Education 4.0 in terms of their technological and digital skills.

Table 7

Mathematics Teachers` Assessment of their Readiness in terms of Technological and Digital Skills

Statements	**Mean** ($\overline{X}$)	**SD** (***s***)	**Verbal Description**
I am ready to use virtual reality as object of mathematics learning in my instruction.	2.46	0.65	Disagree
I am ready to transform my traditional learning environment to virtual environment.	3.02	0.67	Agree
I am ready to utilize augmented realities in teaching mathematics.	2.43	0.70	Disagree
I am ready to apply artificial intelligence given a chance to teach mathematical modelling.	2.42	0.70	Disagree
I am ready to create and design interactive system in math discussions.	2.46	0.65	Disagree
I am ready to maximize the use of mobile technology in my mathematics instruction.	2.83	0.67	Agree
I am ready to use Flipped Classroom as a teaching strategy in mathematics.	2.50	0.66	Disagree
I am ready to use Social Network-Based Learning in my instruction.	3.01	0.63	Agree
I am ready to enable students to be creative in their learning through using Blended Learning in math classroom.	2.65	0.63	Agree
I am ready to use different online assessment tools in assessing students` mathematical performance.	3.21	0.63	Agree
I am ready in using e-portfolio as summative form of mathematics assessment.	3.08	0.64	Agree
I am ready in using Learning Management System (LMS) in teaching mathematics.	2.45	0.62	Disagree
I am ready to develop electronic learning activities that encourage my students to be critical thinking learners.	3.00	0.67	Agree
I am ready to convert the printed content and activities in the curriculum to the digital.	3.02	0.65	Agree
I am ready to facilitate hybrid learning strategy in mathematics	2.43	0.63	Disagree
Grand Mean	**2.73**	**0.65**	**Agree**

Result revealed that the respondents have agreed in 8 out of 15 indicators while they disagreed in 7 out of 15 indicators of their readiness in terms of their technological and digital skills aligned to the challenge of Mathematics Education 4.0. Mathematics teachers assessed that they have

low level of readiness in terms of using virtual realities; using augmented realities; applying artificial intelligence; creating and designing interactive systems; using Flipped Classrooms; using Learning Management System; facilitating hybrid learning in mathematics. Moreover, the respondents have high level of technological and digital skills readiness in terms of using social network based learning; dealing with virtual environment; developing electronic learning activities; and preparing digital curriculum.

Descriptive Analysis of Mathematics Teachers` Professional Skills Readiness

Table 8 features the mathematics teachers` assessment of their readiness in Education 4.0 in terms of their professional skills readiness. As can be viewed on the table, result showed that the respondent agreed in all indicators assessing their professional skills readiness which will be needed in preparation for the impact of industrial revolution in education.

Table 8

Mathematics Teachers` Assessment of their Readiness in terms of their Professional Skills.

Statements	**Mean** ($\bar{x}$)	**SD** (***s***)	**Verbal Description**
I am ready to train my students to apply theoretical knowledge and use human reasoning to examine the patterns and predict trends.	3.04	0.60	Agree
I am ready to communicate well to my students in any forms of learning.	3.14	0.58	Agree
I am ready to be flexible in converting my instruction into different forms whenever needed.	3.13	0.57	Agree
I am ready to train my students to be creative and critical thinkers as well as problem solvers.	3.17	0.59	Agree
I am ready to play roles such as facilitator, online content curator, activity organizer, and project designer instead of mere transmitter of knowledge.	3.08	0.63	Agree
I am ready to develop the skills of my learners to transform math ideas into practice.	3.17	0.56	Agree
I am ready to integrate practical and experiential learning-based projects or field works in my math instruction.	3.12	0.57	Agree
I am ready to expose students to more hands-on learning through field experience such as mentoring projects and collaborative projects.	3.10	0.61	Agree

I am ready to create activities that enable students to develop their data interpretation and data analytics in applying their theoretical knowledge in their math subject.	3.08	0.58	Agree
I am ready to create flexible math assignments which will accommodate students` multiple learning styles.	3.15	0.56	Agree
I am ready in facilitating problem and project- based learning strategies in mathematics.	3.09	0.55	Agree
I am ready that I can integrate application-oriented learning in my math instruction.	3.11	0.55	Agree
Grand Mean	**3.11**	**0.58**	**Agree**

Respondents have an overall assessment of high level of professional skills readiness having a computed grand weighted mean of 3.11 and standard deviation of 0.58. It can be noticed also that they are 100% agree in all of the indicators. This implies that mathematics teachers are professionally ready to face the challenges of Education 4.0 in their field.

Descriptive Analysis of Mathematics Teachers` Professional Skills Readiness

Table 9 exhibits the mathematics teachers` assessment of their readiness in Education 4.0 in terms of their lifelong learning and personal skills.

Table 9

Mathematics Teachers` Assessment of their Readiness in terms of their Professional Skills

Statements	**Mean** $(\bar{X})$	**SD** ***(s)***	**Verbal Description**
I am ready to learn more as a math instructor by exploring different strategies that will help my students.	3.35	0.67	Strongly Agree
I am ready to be updated of the newest trends and innovative strategies In mathematics education.	3.34	0.67	Strongly Agree
I am ready to attend to different seminars, workshops, and trainings that I can use to adapt in the new trends in the educative system.	3.37	0.66	Strongly Agree
I am ready to motivate my students to do their best in learning mathematics.	3.38	0.68	Strongly Agree

I am ready to value patience in teaching mathematics whenever online or face-to-face.	3.38	0.66	Strongly Agree
I am ready to adapt with different types of learners.	3.38	0.65	Strongly Agree
I am ready to be flexible enough to face all the challenges brought about this revolution in mathematics education	3.36	0.66	Strongly Agree
I am ready to be appreciative in any progress of my students in mathematics	3.39	0.63	Strongly Agree
I am ready to serve as a counselor to my students having difficulty in mathematics	3.41	0.64	Strongly Agree
I am ready to be a critical thinking teacher in this era in education	3.37	0.64	Strongly Agree
Grand Mean	**3.37**	**0.65**	**Strongly Agree**

As revealed on the data, it only shows that mathematics teachers have a very high level of readiness when it comes to their lifelong learning and personal skills. Data manifested that the respondents strongly agreed in all indicators assessing their skills readiness particularly their lifelong learning and personal skills. This implies that they are highly ready to learn more about new learning strategies employed in Education 4.0. They are highly ready when to be updated on the newest trends and innovative strategies used in mathematics education. Moreover, they have also high level of readiness in attending different seminars, workshops, and trainings relative to new revolution in education and highly ready to be flexible enough to face all the challenges brought about by Education 4.0. In terms of their personal skills, they are highly ready in terms of being a critical thinking teacher; serve as guidance counselor; appreciative in any progress of students; motivate students to do always their best; and adapt to different types of learners in the classroom.

Correlation Analysis between Mathematics Teachers` Competence and Skills Readiness

Table 10 illustrates the test of significant relationship between teachers` competence and skills readiness towards educations 4.0.

Table 10

Correlation between Mathematics Teachers` TPACC and Skills Readiness towards Mathematics Education 4.0

Variable	**Skills Readiness towards Mathematics Education 4.0**	
	R	**Significance**
Teachers` TPACC towards Mathematics Education 4.0	0.870**	0.000

Result showed that the Technological Pedagogical and Content Competence Variable variables significantly correlated with the variables of skills readiness towards Mathematics Education 4.0 (** r = .870, p <.01). The findings of the analysis of the correlation test showed a strong positive correlation level. This shows that teachers` high level of competencies on TPACC means high level of skills readiness towards Mathematics Education 4.0. Teachers must be competent in teaching so that teaching and learning objectives can be achieved in which the students acquire knowledge and skills.

To determine the views of the participants with both low levels of competence and skills readiness towards mathematics education 4.0 regarding their recommendations and suggestions on how they will face the challenge of Industry 4.0, transcript of responses is shown below.

More Seminars, Trainings, and Workshops relative to Mathematics Education 4.0

"More seminars, trainings, and workshops about the relationship of Industry 4.0 and Mathematics Education 4.0. We should be trained about integrating technology in the classroom, maximizing the use of ICT, internet connections and social media in mathematics instruction" (FM-1)

"Teachers need trainings about artificial intelligence, virtual and augmented realities, learning management system, and interactive systems." (FM-2)

"There should be seminars/ webinars about different strategies and trainings about technologies used in teaching mathematics under Education 4.0. (FM-3)

"More trainings and seminars about what to be expected from a teacher, learner, and learning environment in this revolution on education." (FM-4)

"Teachers should be trained in all tools, devices, and software applications that will be used for education 4.0. They should be trained about various strategies used in mathematics classroom." (FM-5)

"Educators should be trained on smart technology, artificial intelligence, and robotics since these are some of the highlights on Education 4.0" (FM-6)

"Teachers should be trained about the use of technological and digital tools used in teaching under the new era of industrial revolution." (FM-7)

As viewed on the responses of the participants, they have suggested that there should more trainings, workshops, and seminars concerning newest trends in Education 4.0 its strategies, technological advancements, new digital tools, technological tools and devices as well as ICT equipment, Beetham and Sharpe (2013) believe that digital technology facilitates and increases interactions between teachers and students and transforms teaching and the learning process. Finally, according to the European Commission research (2019), teachers agree with the fact that the use of ICT in teaching and learning has a positive effect on the performance, motivation and development of students' transversal skills (critical thinking, analysis, problem solving, social skills)

Government Support in Enhancing Educational Facilities

"More funding on infrastructures and ICT equipment to further improve classroom facilities"- (FM-1)

"The government should provide more financial support to educational institutions in procuring needed ICT equipment such as smartboard, computers, projectors, etc. which will be used in teaching instruction in this era of educational revolution" (FM-2)

"Administrators and those in higher authorities should allot budget on building multimedia classrooms, laboratories, audio-visual rooms since this is the only way to enhance educational facilities aside from buying ICT tools and devices. (FM-5)

As can be observed on the transcribed responses of the participants, it only showed that their recommendations and suggestions focuses on the support of government in enhancing educational facilities like building

infrastructures specifically laboratory, audio-visual, and multimedia rooms. They also suggested that there should be funding or budget for the procurement of ICT equipment. In the study conducted by Jo and Lim (2015), practical government support is needed and important in developing the technology-based classrooms into the 21st century skills. Male (2016) commented that incorporating technology into classroom will offer a greater opportunity to change the way teachers engage with their students that will result in better networking, collaborative learning and problem solving which is in line with the study conducted by Anealka & Hussin (2018).

V. CONCLUSION AND RECOMMENDATIONS

The present findings provide insight on the present levels of teachers` competence and skills readiness towards Mathematics Education 4.0. It shows that mathematics teachers have low level of competence on integrating technology in their pedagogy. They have also manifested low level of competence on the required instructional strategies and technological and digital tools relevant to Education 4.0 More broadly, the findings speak to the issue of low level of skills readiness on their technological and digital literacy. This research showed that teachers have high level of competence in terms of their pedagogical and content competencies in mathematics. Moreover, they also have high level of skills readiness on their professional and personal skills which will be needed to face the challenges brought about by new revolution in the era of education. The study also revealed that there is a positive correlation between teachers` competence and skills readiness towards mathematics education 4.0 which implies that both constructs should be taken into consideration when preparing for the full impact of Industry 4.0 to education. Lack of trainings, seminars, workshops, and government support was also addressed in this research. With these, administrators and educators should give their efforts to initiate actions on the problem arising wherein they should be proactive of the upcoming demands of Industry 4.0 on education. They should work hand in hand in order to attain the smooth integration of technology on Mathematics Education 4.0. Funding for ICT equipment, building infrastructures, and other technological and digital tools is very much needed. Seminars, workshops, and trainings relevant to Education 4.0 are also vital to increase the awareness and readiness of teachers in teaching in Mathematics Education 4.0.

Mathematics educators, researchers, and administrators of higher educational institutions may give at least as much attention to the impact of Industry 4.0 to mathematics education. More precise trainings about how to become mathematics teachers 4.0 should be taken into consideration. The must be proactive in aligning their teaching and processes with technological advancements.

To enrich these findings, future researchers may consider longitudinal studies and other programs to elucidate more clearly the roles of administrators, mathematics teachers, students, and parents in Education 4.0. These results would encourage other researchers to give at least as much attention on strategies to be employed on this era on education to prepare future graduates for work in the fourth industrial revolution where artificial intelligence and robotics exist.

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