Mathematical Readiness of Freshmen Engineering Students (K-12 2020 Graduates) in Eastern Visayas in the Philippines

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Abstract: This study assessed the mathematical and analytical readiness of the incoming first-year college engineering students (K-12 2020 graduates) in Eastern Visayas in the Philippines. First-year engineering students (n=177) participated in the College Math Readiness Test (CMRT), a questionnaire on mathematics subjects that covered Precalculus, Analytical Geometry, Series and Mathematical Induction, Trigonometry, and Basic Calculus: Limits and Continuity, Derivatives, and Integration. The findings indicate that 43% of the respondents were mathematically-college-ready (MCR) and 57% were not-mathematically-college-ready (NMCR). Regarding the NMCR, 39% fared fairly and 18% fared poorly in the CMRT. This suggests that remedial support for mathematics for this group may be required for them to be college-ready for an engineering course. The respondents had the lowest correct mean score for the Integration subjects: Evaluating Differential Equations (15%), Evaluating Definite Integrals (16%), and Solving Area Between Curves (19%). The results of the ranking of the Senior High Schools (SHS) showed that 13 SHS with at least 2 takers and 24 SHS with single takers need to improve their quality of teaching to enhance the mathematical competence of their graduates. The findings of this study were used to identify remediation areas and recommendations to improve the students' college mathematical and analytical readiness.

Keywords: K-12, college-math-readiness, engineering students, Philippines

1. Introduction

This study was undertaken to investigate the impact brought about by the implementation of the Enhanced Basic Education Act of 2013 or K-12 to the Philippine educational system, specifically, its effect on the mathematical and analytical readiness of the incoming first-year college engineering students (K-12 2020 graduates) in Eastern Visayas in the Philippines. The 2020 graduates are the 3rd batch of K-12 alumni since the Enhanced Basic Education Act of 2013 was implemented. Due to some of the concerns about the quality of K-12 education in its early stages of implementation (Ke-Du, 2019; Mamba et al., 2020), this study was conceived to answer the basic question ‘Are the K-12 graduates prepared, mathematically and analytically, to pursue an engineering course in college?’ To put this question in perspective, when the Philippines Department of Education implemented the Republic Act (RA 10533) otherwise known as the Enhanced Basic Education Act of 2013, it led to the creation of a Senior High School Program with an additional two years of basic education. Before the K-12 program was implemented, basic education in the Philippines consisted of six (6) years elementary and four (4) years secondary education (Adarlo & Jackson, 2017). After the K-12 program was enforced, the basic education program became three levels: six (6) years of primary education, four (4) years of Junior High School, and two (2) years of Senior High School (SHS).

Consequently, after RA 10533 was implemented, the subjects that used to be offered at the tertiary level were included in the Senior High School Curriculum. These subjects included General

Mathematics, Pre-Calculus (Algebra, Trigonometry, Analytic Geometry), Probability and Statistics, and Basic Calculus (Limits and Continuity, Derivatives, and Integration). As a result, the 5-year college engineering course was reduced to 4 years because of the movement of general education mathematics subjects to the Senior High School curriculum.

The K-12 program was aimed to comprehensively reform the Philippines' basic education (Okabe, 2013; DepEd, 2013) to enable it to catch up with global standards. The K-12 program and its format is widely adopted internationally i.e., K-12 is implemented in the United States (Dugger, 2010; Watson & Murin, 2014), Afghanistan (Yazdi, 2008), Australia (Hynes et al., 2017), Canada (Beveridge et al., 2019), China (Johnson et al., 2016), South Korea (Joo et al., 2016), and Turkey (Kucuk et al., 2013), to mention a few. The RA 10533 implementation in the Philippines was anticipated to churn out graduates that are prepared for college with the help of a well-developed and well-designed curriculum. The K-12 curriculum was designed to (a) provide a set of specific competencies through the provision of an appropriate track and strand to every student, (b) ensure that the student is ready for further studies towards a baccalaureate degree, and (c) to ensure that the basic K-12 education that the student receives conforms with the international standards (Braza & Supapo, 2014).

When the K-12 educational reform started, the Commission on Higher Education prepared initiatives to create a smooth transition for the graduates from basic education to higher education. These initiatives have included the development of the college readiness framework (Magno & Piosang, 2016). The college readiness framework details the topics and competencies that a typical senior high school graduate needs to learn in the areas of science (biology, chemistry, physics, earth science), mathematics, English, Filipino, Literature, humanities, and the social sciences. College readiness (Conley, 2007) means a student's preparedness to enrol and succeed at a collegiate institution that offers a baccalaureate degree. On the other hand, in the Philippines, readiness is determined based on the Policy Guidelines on the National Assessment of Student Learning for the K-12 Basic Education Program (DepEd, 2016) through the Basic Education Exit Assessment (BEEA) for graduating senior high school students. This examination is used primarily in relation to DepEd's feedback mechanism and not as a college entrance examination (Mamba et al., 2020). Perhaps the assessment is not entirely geared towards measuring the college readiness of K-12 graduates.

This study was undertaken to investigate and answer the following questions: Are the K-12 Senior High School graduates mathematically college ready? Is there a difference in mathematical preparedness between and among the graduates of specific K-12 tracks? If not, is there a need to make adjustments in the curriculum at the Senior High School level to achieve the desired and expected college mathematical preparedness? If so, is there a need for the receiving tertiary institution to provide interventions in the form of prerequisite mathematics subjects or remediation classes? These questions are unavoidable because when sudden educational change and innovation are implemented considerably, the outcome may not be favourable as there is always a resistance to change particularly when it is implemented in a top-down approach (Ke-Du, 2019). Assessments and studies similar to this research can help evaluate the program and determine the effectiveness of its implementation. This can also provide input to policymakers, curriculum developers, teachers, and school administrators on the methods and ways to fine-tune the K-12 curriculum.

2. Methodology

This study used a quantitative-descriptive-survey approach to research and determine the mathematical and analytical readiness of the incoming first-year college engineering students (K-12 2020 graduates) in Eastern Visayas, Philippines. The study developed a College Math Readiness Test (CMRT), a test questionnaire on mathematics that covered Pre-calculus and Basic Calculus, as a systematic tool and method for collecting quantifiable information from the respondents of the study.

2.1 Study Site

This study was conducted in Eastern Visayas in the Philippines (Figure 1). Eastern Visayas consists of three main islands: Samar, Leyte, and Biliran, and it has a population of 4,440,150 inhabitants as of 2015 (PSA, 2015). Eastern Visayas is home to seven (7) state universities: the University of Eastern Philippines (UEP), Visayas State University (VSU), Southern Leyte State

University (SLSU), Naval State University (NSU), Eastern Samar State University (ESSU), Samar State University (SSU), and Eastern Visayas State University (EVSU) where this study was undertaken. EVSU is a public university and the oldest higher educational institution in the Eastern Visayas. It offers degrees in trade, fishery, agriculture, forestry, science, education, commerce, architecture, engineering, and related courses.

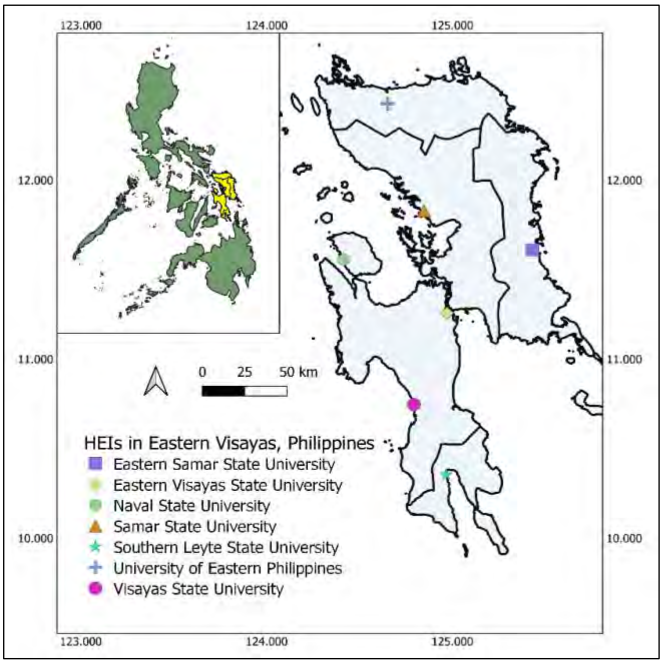

Fig. 1 Location of Eastern Visayas in the Philippines and the Eastern Visayas State University (EVSU) where this study was undertaken.

2.2 Questionnaire Development and Composition

This study used the College Math Readiness Test (CMRT), an assessment tool developed by the researcher in the form of a test questionnaire on mathematics that covered Pre-calculus: Analytic Geometry, Series and Mathematical Induction, and Trigonometry; and Basic Calculus: Limits and Continuity, Derivatives, and Integration. The questionnaire was mainly composed of standardised mathematical questions for freshmen engineering students, defined as the questions used in the college examinations when the subjects are taught in a tertiary institution i.e., EVSU).

The CMRT was divided into three parts as follows. (1) General Information (name, school, selected track, and strand, selected course). (2) Pre-calculus learning competencies as stipulated in the curriculum guide of the Senior High program. his is taught for 80 hours and covers Analytic Geometry, Series and Mathematical Induction, and Trigonometry. This part had 30 questions, specifically 10 questions for every component in increasing difficulty. (3) Basic Calculus learning competencies taught for 80 hours and covering Limits and Continuity, Derivatives, and Integration. This part had 30 questions with 10 questions for every component in increasing difficulty. The questionnaire had 60 test questions in total and was answerable over a time period of 2 hours. An additional 10 minutes was allotted to the general information section of the questionnaire.

2.3 Test Questionnaire Reliability and Validity

The questionnaire's reliability was determined through a test-retest approach (two-week interval) by administering the same questionnaire to a group of 1st-year engineering students (n=31) twice. Questionnaire reliability refers to its consistency in yielding results or measurements every time it is used (Miller et al., 2013; Nasab et al., 2015). The correlation results of the test-retest method showed a high value of r = 0.89, likely indicating the moderately high consistency of the questionnaire. This also perhaps signifies that it would produce the same results if administered again in comparable conditions.

The questionnaire's content validity was determined through a process of review and validation to ensure that the content and meaning of the questions adequately covered and captured the subject matter, and that it was sufficient to measure the knowledge and proficiency of the respondents. The questionnaire was reviewed and validated by the teachers (n=3) that were handling mathematics subjects from three different Senior High Schools in Eastern Visayas. The teacher's role was (1) to recommend the passing score, and to provide comments and suggestions to improve the questionnaire and (2) to rate the relevancy of each question (I-CVI) on a scale of 1 to 4, with 1 being the least relevant and 4 as being very relevant. The scale content validity index /average (S-CVI/Ave) was calculated by taking the sum of the I-CVIs divided by the total number of items. The S-CVI/Ave of the CMRT was determined to be equal to 0.92 which is an acceptable content validity index (Shi et al., 2012). Additionally, Fleiss kappa (a version of Cohen's kappa for >3 raters) (McHugh, 2012) was calculated to determine the inter-rater reliability or the level of agreement of the 3 raters in relation to the relevance of the questions in the CMRT. Fleiss' kappa (κ) was determined to be equal to 0.804 suggesting an acceptable level of agreement among the raters, meaning that it would probably yield a similar rating of relevancy when other experts rate the questionnaire.

The face validity of the CMRT was assessed informally with the help of two colleagues (one has a Ph.D., while the other has a master's degree) of the researcher by evaluating and recommending that improvements be made to the question sentence structure, grammar, correctness, and clarity to avoid the possibility of being misunderstood or there being misinterpreted questions (Stangor, 2014).

2.4 Test Questionnaire Administration

Due to the Covid-19 pandemic that limited face-to-face contact, the researcher administered the questionnaire online from 03 August to 30 September 2020 using Google Forms® (Google LLC, Mountain View, CA, USA) by providing the survey questionnaire uniform resource locator (URL) to as many as possible incoming engineering freshmen students at Eastern Visayas State University (EVSU). The questionnaire contained an introductory paragraph that informed the participants of the aim of the survey and the confidentiality of their responses. During the survey period, the questionnaire was time limited to two hours using the timify.me application.

2.5 Data Analysis and Interpretation

The data analysis employed descriptive statistics. The figures were created using the software Microsoft Excel. The level of mathematical and analytical preparedness of the K-12 2020 graduates was determined using their scores as shown in Table 1.

Table 1. College Math Readiness Test (CMRT) Score, Description, and Interpretation

CRMT Score	Description	Interpretation
50-60	Excellent	Excellently Prepared
40-49	Good	Well Prepared
30-39	Satisfactory	Satisfactorily Prepared
20-29	Fair	Remediation Class Recommended
1-19	Poor	Remediation Class Required

3. Results

3.1 Respondents Profile

A total of 177 incoming first-year college engineering students that graduated from sixty-seven (67) different Senior High schools in Eastern Visayas in 2020 responded to the survey. The sex ratio of the respondents was 48% female and 52% male. The age composition of the respondents was 19 years old comprising 21%;18 years old, 63%; 17 years old, 10%, while the rest were either 16, 20, or 21 years old. Other studies reported that academically, male students were better prepared for college-level mathematics than female students (Atuahene & Russell, 2016). However, this is not the case in this study, although a male respondent obtained the highest score at 53 points. There was found to be no difference in score (mean ± SD) between the sexes (females, $\mu = 28.5 \pm 8.9$; and male, $\mu=28.4 \pm 9.9$) otherwise.

The majority of the respondents (88%) were taking a Bachelor of Science in Civil Engineering, 7% were undertaking a Bachelor of Science in Electrical Engineering, and 5% were taking a Bachelor of Science in Computer Engineering.

3.2 Mathematical and Analytical Readiness

The results show (Figure 2) that 43% of the respondents were mathematically-college-ready (MCR) as incoming first-year engineering students. They were distributed as follows: 28% are satisfactorily prepared, 13% are well prepared, and 2% are excellently prepared. However, 57% of the respondents were not-mathematically-college-ready (NMCR) and were distributed as follows: 39% fared fairly, and 18% fared poorly.

Among the various mathematics subjects (Figure 3), the respondents obtained the lowest mean percentage correct scores for Integration (36.6%) and Derivatives (39.2%). The respondents fared satisfactorily for Limits and Continuity (47.7%) and Trigonometry (46.7%), and they fared well in Series and Mathematical Induction (58.3%) and Analytic Geometry (58.2%).

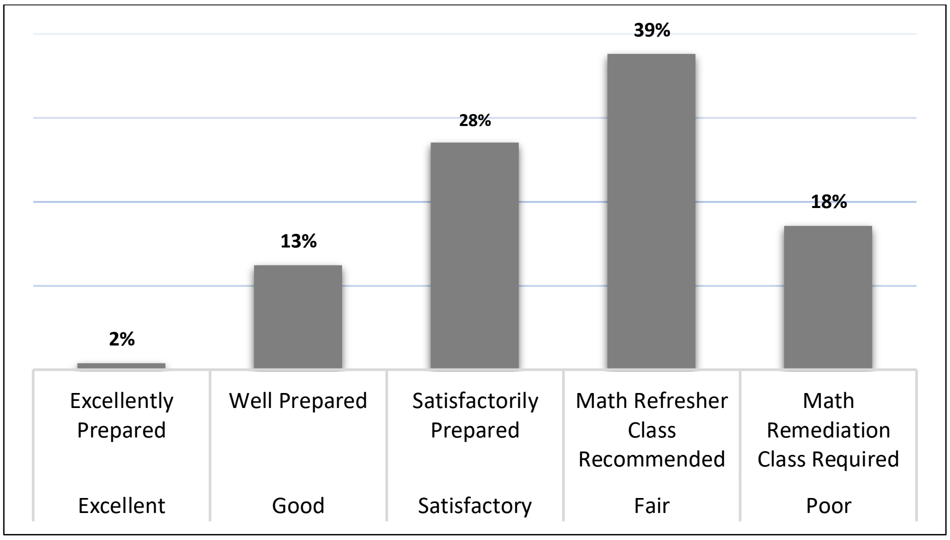

Fig. 2. Mean percentage correct score: Excellent (2%), Good (13%), Satisfactory (28%), Fair (39%), and Poor (18%) indicating the mathematical and analytical readiness of the respondents (*n*=177).

3.3 Student Tracks and Strands

The strand distribution of the respondents is shown in Table 2. The strand of MCR (95%) students was mostly from either STEM (79%) or General Academic (GA) at 16%. For NMCR, 75% of the students were also mostly from either STEM (49%) or GA (26%).

The track distribution of the respondents shows that 99% of the MCR students were mostly from either the Academic Track (GT) by 90% or the Technical-vocational-livelihood Track (TVLT) by 9%. Similarly, 98% of the NMCR were mostly from either GT (65%) or TVLT (33%). This similar distribution of track and strand for both MCR and NMCR is because the respondents are freshmen engineering students (K-12, 2020 graduates).

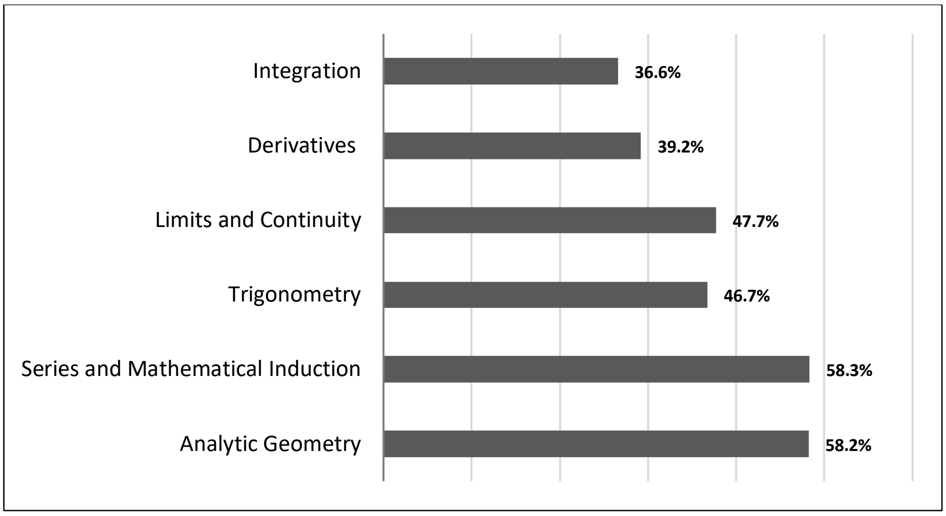

Fig. 3. Mean percentage correct score of the respondents (*n*=177) based on subject category; The Pre-Calculus subjects were Analytic Geometry (52.8%), Series and Mathematical Induction (58.3%) and Trigonometry (46.7%). Basic Calculus was Limits and Continuity (47.7%), Derivatives (39.2%), and Integration (36.6%).

Table 2. Tracks and strand distribution of the mathematically-college-ready (MCR) and the not-mathematically-college-ready (NMCR) students.

Strand	Not College Ready (NMCR) 57% (*n*=102)	College Ready (MCR) 43% (*n*=75)
STEM	49% *n*=50	79% *n*=59
HUMSS	14% *n*=14	1% *n*=1
General Academic (GA)	26% *n*=27	16% *n*=12
ABM	8% *n*=8	4% *n*=3
Pre-Baccalaureate Maritime	3% *n*=3	0% *n*=0
Track		
Academic Track (GT)	65% *n*=90	90% *n*=66
Sports Track	2% *n*=1	1% *n*=1
Technical-vocational-livelihood Track	33% *n*=11	9% *n*=8

3.4 Least Mastered Math Skills

Table 3 shows the least mastered mathematics skills of the respondents based on the correct mean percentage score of all takers. This was defined as the questions answered correctly by <50% of the respondents. The results showed that for the Pre-Calculus subject: Analytic Geometry, both Analysing a Parabola and Analysing a Circle were answered correctly by 32% of the respondents while Analysing a Hyperbola were answered by 40% correctly. For Series and Mathematical Induction, Evaluating Summation or Sigma Notation was answered correctly by 32%, and the questions on Proving by Mathematical Induction were answered correctly by 40% of the respondents. Additionally, for Trigonometry, Trigonometric Identities was answered correctly by 9%, Graphing Sine and Cosine Functions by 30%, and Solving Trigonometric Equations by 32% of the respondents.

The respondents found the Basic Calculus subjects to be more difficult as they obtained a much lower correct mean percentage score i.e., in Limits and Continuity, the subject Evaluating Limit Given the Graph of the Function was answered by 25% of the respondents. For Derivatives, the Quotient Rule and Product Rule was answered by 27% and 23% of the respondents, respectively. The respondents had the lowest correct mean percentage score in Integration: Evaluating Differential Equations and it was answered by just 15%, followed by Evaluating Definite Integrals by 16%, and lastly, Solving Area Between Curves by 19% of the respondents.

Table 3. The least mastered math skills of the respondents (n=177) and their mean percentage correct answers (MPCA).

Subject	**Content**	**MPCA**
Pre-Calculus		
Analytic Geometry	Analysing a Parabola	32%
	Analysing a Circle	32%
	Analysing a Hyperbola	40%
Series & Mathematical Induction	Evaluating Summation of Sigma Notation	32%
	Proving by Mathematical Induction	40%
	Series and Factorial Notations	49%
Trigonometry	Trigonometric Identities	9%
	Graphing Sine and Cosine Function	30%
	Solving Trigonometric Equations	32%
	Trigonometric Ratio in Solving Triangle	40%
	Graphing Secant and Cosecant Functions	47%
Basic Calculus		
Limits and Continuity	Evaluating Limit Given the Graph of a Function	25%
	Solving Limit of a Function	34%
Derivatives	Quotient Rule	23%
	Product Rule	27%
	Finding the Derivative of a Function	32%
	Finding the Second Derivative of a Function	32%
Integration	Evaluating Differential Equations	15%
	Evaluating Definite Integrals	16%
	Solving Area Between Curves	19%

3.5 Senior High School Ratings

The SHS were categorised and rated based on the performance of their senior high school graduates that took the CMRT. A total of 177 incoming first-year college engineering students that graduated from 67 different SHS in Eastern Visayas in 2020 participated in the CMRT. Due to the nature of the data collected where 39 SHS has only 1 taker (1 sample), the researcher grouped the SHS into two categories: (1) with at least 2 takers and (2) with 1 taker.

Table 4. SHS with at least 2 takers (n=28), and SHS with 1 taker (n=39), and the results of the College Math Readiness Test (CMRT).

Number of SHS with at least 2 takers (n =28 SHS)	Number of Takers	Percent College Ready	Mean Percent Correct Score	SHS Rating
3	7	100% (n=7)	62%	Excellent
4	34	76%(n=26)	58%	Very Good
8	43	55%(n=24)	54%	Good
4	16	38%(n=6)	46%	Satisfactory
2	15	14% (n=2)	34%	Fair
7	23	0%(n=0)	26%	Poor
Number of SHS with 1 taker (n =39 SHS)	39	38%(n=15)	45%	Satisfactory

Table 4 shows that at least four (4) SHS can improve the mathematical and analytical college readiness of their graduates from Satisfactory to Good, two (2) SHS need to improve from Fair to, at the very least, Satisfactory, and seven (7) SHS need to badly improve as their graduates as they were found to have poor mathematical and analytical college readiness. The mathematical and analytical readiness of the thirty-nine (39) respondents that came from thirty-nine (39) different SHS suggests that 38% are college-ready with a mean percent correct score of 45%. This indicates that many of these SHS need to improve the quality of their mathematics education.

4. Discussion

The profile of the respondents (*n*=177) revealed an almost 1:1 sex ratio with 48% female and 52% male respondents showing that engineering nowadays may not be a gender-specific career. About 94% of the respondents are in ages 17 to 19, with age 18 representing 63% which is about the right age to start a college education. This study found no difference in scores (mean ± SD) between the sexes (females, $\mu = 28.5 \pm 8.9$; and male, $\mu=28.4 \pm 9.9$). These findings imply that there's no gender gap (Basile, et al., 1995; Atuahene and Russell, 2016) in mathematics ability among the respondents.

In total, 43% (*n*=75), which is less than half, of the respondents are mathematically-college-ready (MCR) while the majority (57%) (*n*=102) are not-mathematically-college-ready (NMCR) to be first-year college engineering students (Table 2). This is unexpected because most of the respondents (88%) were from the academic track, and 62% were from STEM and 22% were from the GA strand. Because of earlier studies reporting that STEM students have higher grades in mathematics than other strands (Aunzo & Lanticse, 2015), it was expected that most of the respondents would be MCR. This was not the case.

Nonetheless, these dismal results confirm the findings of related studies that have reported that the K- 12 graduates in a public university in the north-eastern Philippines had only 37.3% of their admitted freshmen college students for the year 2020 as MCR (Mamba & Vecaldo, 2020). This is aligned with the report of Amanonce (2020) which indicated that many K-12 students are not ready to take college-level mathematics courses. This was again confirmed in another study showing that the K-12 program in the Philippines is not preparing the students adequately for a university STEM degree like engineering (Almerino et al., 2020). Perhaps these related studies, including this research, point towards the need for an admission policy redirection among Higher Education Institutions (HEIs) to enhance the selection and mathematical readiness of its college freshmen students in engineering.

The MCR students (*n*=75) came from the academic track (90%), and STEM strand (79%) which is expected of freshman engineering students. This track and strand profile of MCR students probably suggests that if an SHS student is planning to pursue engineering and other STEM-related degrees in college, then the student should opt for the academic track and STEM strand. STEM raises the likelihood that a student will complete pre-calculus and basic calculus in high school. This has a positive impact on their grade point average (GPA) (Means et al., 2016). STEM involves higher-level mathematics courses than other strands (Amanonce, 2020) thus, the students are more prepared for an engineering course in college (Almerino et al., 2020; Long et al., 2009). Similarly, the NMCR students (*n*=102) had a similar track and strand profile as the MCR. Most of the NMCR students also came from the academic track (65%) and STEM strand (49%). This track and strand profile similarity could also mean that opting for an academic track and STEM is not a guarantee, although it does provide an advantage (Long et al., 2009, Means et al., 2016) when it comes to being MCR for an engineering course in college.

Although the respondent's similarity in terms of their track and strand profiles may suggest homogeneity, the results of the CMRT as shown in Table 4 reveals a disparity in mathematics competency and proficiency among the respondents. The extent of this disparity can be inferred from the variability in the CMRT scores of the respondents that are in STEM by checking the mean (μ), the range (R), the coefficient of variation (CV), and Standard Deviation (SD), all of which are measures of variability. The descriptive analysis results are R=41, CV=29%, μ=31.7, SD =9.25. Kim and Choi (2008) reported that there are several factors that cause a high variability in the achievement levels of students i.e., the variation in maths achievement can be attributed to the individual differences among the students, between-schools as some schools are better than others, on the students' attitude towards maths, and the students after school time management, among other causes.

Nevertheless, this poor mathematics performance and the high variability of the scores begets many questions. Why are most of the K-12 graduates NMCR? Is the poor performance caused by the shift to K-12? Is the variability due to some teachers being more qualified and competent at teaching mathematics than others? The researcher believes that the reasons behind this disparity and the poor performance of the K-12 graduates in college mathematics can be attributed to many causative factors as reported by other studies (Amanonce, 2020; Almerino et al., 2020; Mamba et al., 2020; Mamolo, 2019; Vecaldo et al., 2020). The causative factors may be able to be categorised into four (4) groups, as follows: (a) the students' attitude towards mathematics (Maloney et al., 2013), (b) the quality of the teaching and the teacher's preparedness (Amanonce, 2020), (c) the SHS learning facilities and environment (Mbugua, 2012), and (d) parental support (Jameela & Ali, 2016).

Furthermore, the background information on Table 4 shows that the SHS with excellent, very good, and good ratings are big science SHS situated in urban areas. Those rated satisfactory, fair, and poor are from small community-based SHS located in rural areas. For example, the three (3) SHS rated as excellent, as well as the four (4) SHS that are rated very good, are big to medium SHS located in cities. In contrast, regarding the bottom seven (7) SHS rated as poor, five (5) are small SHS in rural areas hosted by 3rd to 5th class municipalities. Communities in the Philippines are classified, based on income into cities (highest) and municipalities (from 1st to 5th class as the lowest).

Why are the bigger SHS situated in urban areas performing better than the small rural SHS in CMRT? There are potentially many reasons, to cite a few. The students have higher college readiness (Mamba, et al., 2020) when they came from SHS with higher budgetary appropriations and better physical facilities. There are more qualified teachers who prefer teaching in big SHS in cities for numerous reasons (Brillantes, et al., 2019) such as urban convenience, being closer to home and their family, security, and faster upward mobility as it is known that teachers in small rural SHS have limited opportunity for professional growth i.e., seminars, training, and graduate studies. There is also the lesser workload as it is common knowledge that the lack of teachers in rural areas results in teachers handling both JHS and SHS classes. In some cases, this is as well as other SHS subjects that are not in their expertise, resulting in as many as 4 to 5 preparations in a school year (Amanonce, 2020; Brillantes et al., 2019). Nonetheless, this confirms the report of Vecaldo (2020) that college preparedness scores are affected by the type of SHS, with public agriculture/fishery/technical/vocational SHS obtaining significantly lower scores than those who graduated from the other types of SHS. Kim and Choi (2008) also reported that socioeconomic status and school location were closely related to the student's achievement at the school level. Students from low-quality SHS commonly received a low quality of instruction from less pedigreed high school teachers (Atuahene & Russell, 2016).This means that they may not have the opportunity to take advanced-level courses and, as a result, many may not be ready for college-level mathematics (Sterling, 2004).

How can this study help the identified NMCR improve their mathematical skills to enable them to finish their education in engineering? HEIs, unquestionably, play a major role in addressing these concerns by providing the necessary academic support services to students who are considered academically underprepared for college-level mathematics. Understanding and applying an accurate and in-depth intervention can help the students improve their mathematics proficiency (Atuahene & Russell, 2016). It is the opinion of this study that HEIs should respond to this concern by institutionalising college maths readiness evaluations including offering remedial classes to those identified as NMCR. Remedial classes are the subjects that are required for students to improve their mathematics competencies before they can continue studying engineering comfortably. Mathematics remediation for engineering undergraduates is not a new trend (Eleri et al., 2007).

There were found to be 57% (n=102) respondents categorised as NMCR. This group may need remediation classes to be college-ready for an engineering course. One significant factor preventing the students from studying engineering is a lack of mathematical expertise (Eleri et al., 2007). Other studies suggest that mathematics remedial courses could have mixed benefits (Calcagno & Long, 2008), thus they should be designed following the results of an assessment of the students' mathematical and analytical readiness. The objective of these remedial classes should be to help the students catch up with their classmates, to reduce their anxiety, and to help them gain increased confidence, enough so to effectively engage with the engineering subject later on (Eleri et al., 2007). Remedial classes and mathematics enhancement programs promote early persistence in college (Calcagno & Long, 2008) and they can help struggling students to improve their math skills as reported by Venegas-Muggli et al. (2019). They found that mathematics remedial courses lead to better academic results than those with similar characteristics who did not take remedial classes. It also helps the students complete their course of study and means that they are less likely to stop or drop out (Radford et al., 2012). Apart from remedial classes, a mentoring program for the students could also be initiated, which in other studies has been found to be helpful and moderately effective (Chong & Thi, 2020) at improving the students' academic performance and at providing academic subject knowledge support to freshmen students. For students who need refresher courses, a mathematics boot camp may be what they need. Boot camps are designed to help students become ready for the rigors of university-level academic courses and they are usually designed to prepare students for the calculus classes that will lay the foundation of the mathematics needed for their engineering careers (Borgaonkar, 2015).

For a general outline of remediation subjects suited to the 102 NMCR students, Table 3 shows the least mastered mathematics skills of the respondents and so could serve as a reference. The results of the mathematical and analytical readiness evaluation of the incoming first-year college engineering students (K-12 2020 graduates) using a mathematics survey questionnaire showed that for Pre-calculus, the respondents found the following subjects difficult because less than 40% of the respondents answered the questions correctly: Trigonometric Identities (9%), Graphing Sine and Cosine Function (30%), Solving Trigonometric Equations (32%), Analysing a Parabola (32%), Analysing a Circle (32%), and Evaluating the Summation of Sigma Notation which was answered correctly by 32% of the respondents. Furthermore, for Basic Calculus, the respondents found the following subjects difficult as less than 30% of the respondents answered the questions correctly: Evaluating Differential Equations (15%), Evaluating Definite Integrals (16%), Solving Area Between Curves (19%), Quotient Rule (23%), Evaluating Limit Given the Graph of a Function (25%), and Product Rule (27%).

These findings from the mathematical and analytical readiness evaluation of the incoming first-year college engineering students (K-12 2020 graduates) could guide the Higher Education Institutions (HEIs) in Eastern Visayas when crafting the curriculum content of its remediation courses for NMCR freshmen students. This study should also serve as a guide for the teachers in the various SHS in Eastern Visayas to assist them in crafting an improvement intervention approach in their respective Grade 12 mathematics classes.

5. Conclusions

This study concludes with the following deductions. (a) Most of the respondents totalling 57% (n=102) are not-mathematically-college-ready (NMCR), while only 43% (n=75) are mathematically-college-ready (MCR). (b) The students' track and strand probably affects the mathematical and analytical readiness of the students with those from an academic track and STEM strand expected to be MCR. (c) Given how it relates to an academic track and STEM, the subject does not guarantee a student to be MCR for an engineering course in college as there are many other factors that affect the student's MCR. (d) A CMRT score range of 41 (min=12, and max=53) is probably indicative of a disparity in K-12 education quality among the 67 SHS in Eastern Visayas. (e) The possible disparity in K-12 education quality could be attributed to many causative factors such as a lack of education facilities, classrooms, desks, chairs, textbooks, and audio-video materials, as well as a lack of teachers including the dearth of continuing professional development, and skills upgrading programs, to mention a few. (f) The SHSs with excellent, very good, and good ratings are mostly from the big SHS situated in urban areas. Those with ratings of satisfactory, fair, and poor were from small SHS located in far away and economically poor municipalities in rural areas. (g) The student respondents categorised as NMCR (n=102) probably need remediation classes to be college-ready for engineering courses and lastly, (h) the Pre-calculus subjects that the respondents found difficult were Trigonometric Identities, Graphing Sine and Cosine Function Solving Trigonometric Equations, Analysing a Parabola, Analysing a Circle, and Evaluating the Summation of Sigma Notation. On the other hand, for Basic Calculus, the respondents found the following subjects difficult: Evaluating Differential Equations, Evaluating Definite Integrals, Solving Area Between Curves, Quotient Rule, Evaluating the Limit Given the Graph of a Function, and Product Rule.

6. Recommendations

This study recommends the following improvements. (a) SHS students should be informed of the repercussions of their choices of track and strand as this has possible implications on their mathematical and analytical readiness if they are planning to pursue engineering in college. (b) Teachers in SHS should be made aware of the required and prerequisite mathematics competencies needed for an engineering course in college so then their students can be prepared and made ready early on. (c) The teachers probably need further educational training, faculty development programs, instructional preparedness in mathematics teaching, and educational materials and equipment to help them provide a quality mathematics education to K-12 students. This is important as it has been pointed out in another study (Mamolo, 2019) that many SHS teachers were not ready during the implementation of the subject in senior high school. (d) The gap in mathematics education quality between the big science SHSs situated in urban areas and small rural SHSs should be investigated and addressed by the DepEd. (e) There may be a need for an admission policy redirection among the HEIs to enhance the selection and mathematical readiness of its college freshmen students in engineering. (f) Receiving tertiary institution should provide an intervention in the form of prerequisite mathematics subjects or remediation classes to those who need them. (g) Lastly, a more comprehensive research should be undertaken with a much bigger sample size to come up with an accurate and meaningful assessment of the various SHS in Eastern Visayas, the quality of the regional mathematics teaching, and the competency of the SHS graduates.

7. Limitations

First, due to the Covid-19 pandemic that limited face to face contact, the researcher administered the questionnaire online. This constrained the data gathering of the study resulting in a small sample size (n=177 respondents), although the sample is fairly representative of the number of SHS in Eastern Visayas (n=67 SHS). Still, the researcher is apprehensive of the questionnaire administration as it is difficult to determine the reception, engagement, and treatment accorded by the respondents to the online questionnaire. Secondly, the data in Table 4 should be treated with caution due to the small sample size from each SHS. This problem could have been mitigated and uncertainty reduced by averaging over a large number of observations/samples. Nonetheless, the researcher considers Table 4 to be a good reference as it provides a snapshot of the mathematical and analytical readiness of SHS graduates, including the indicative performance of the 67 SHS in Leyte and Samar.

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