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# Teaching of geometry and trigonometry across all strands in senior high school: Its effect in students' mathematics performance

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***Abstract***

This study primarily aimed to determine if additional subjects in Mathematics in Senior High School could improve learners' performance. A total of 455 Grade 11 and 226 Grade 12 learners from the eight (8) senior high schools in the division participated in this study. This research used pretest/posttest quasi-experimental design. Data retrieved were analyzed primarily using frequency counts, mean, standard deviation and paired t-test. This study found that the level of performance of the majority of the learners increased after the implementation of the intervention. Furthermore, there was a significant difference in the performance of Grade 11 and Grade 12 learners before and after the intervention. For intervention adoption, this study recommends that Geometry and Trigonometry should be offered as an add on subjects in senior high school across all strands. Thus, there is a need for the DepEd Central Office Curriculum and Instruction Division to revisit the K to 12 Curriculum for the incorporation of these subjects.

***Keywords:*** senior high school, mathematics performance, geometry, trigonometry, general mathematics

# Teaching of geometry and trigonometry across all strands in senior high school: Its effect in students' mathematics performance

## 1. Introduction

Based on the data presented by the two universities (Eastern Visayas State University and Visayas State University) during the Virtual Consultative Conference with the CHED, PASUC, and DepEd last February 10, 2021, the results of the entrance examination for engineering and architecture participated in by the senior high school graduates show that the number of passers was decreasing. They stressed that senior school students were not equipped on the mastery of mathematical skills as expected when they enrolled in college. Moreover, they found out that more than 50% of those students who were enrolled in STEM could not pass the entrance examination in college for those who wished to take up engineering courses. This scenario is aggravated by the fact they presented that there is no significant difference in passing percentage of STEM graduates with the rest of the graduates of the other strands. Moreover, these two (2) universities claimed that SHS graduates coming from the different strands were not doing well in Geometry and Trigonometry. These scenarios captured the attention of the proponent to investigate.

In consultations with the Math Teachers in STEM and other strands, they have observed that General Mathematics is overloaded with topics that it's almost impossible for the teacher to cover all the topics in a semester. Furthermore, a certain teacher from Maasin City National High School presented the topics of General Mathematics to her professor in a private university in Cebu, the professor observed and noted that General Mathematics in senior high school has lots of topics to be delivered in a semester which is too ambitious. This observation is substantiated by (Ojimba, 2012) who said that undue emphasis on the coverage of mathematics syllabus at the expense of meaningful learning of mathematics concepts is one of the causes why senior high school student perform not so well. Howson and Wilson (1986) stressed that a major reason for the persistence of the special place held by Mathematics in the school curriculum is the way in which it has been used in the last two centuries as a screening device, or filter, for entry to numerous professions. Moreover, the competence gain in the study of Mathematics is widely used in all part of human life. Mathematics plays a key role in shaping how individuals deal with the various spheres of private, social, and civil life (Anthony & Walshaw, 2009). This justifies the compulsion of the study of the subject by all students who go through basic and secondary education in most countries.

Trigonometry is important to Mathematics as an element of calculus, statistics, and linear algebra. Outside of mathematics, it is important to physics, engineering, geography, and astronomy as well as architectural design. Common practical, modern applications of trigonometry include its use in satellite navigation, naval and aviation industries, the composition of music, and all types of digital imaging. It has also become critical in the construction of modern buildings. According to Hushkowtiz, Bruckhenier and Vinner (1987), a basic knowledge of geometric concepts, their attributes and simple relations is fundamental for children to interact effectively with their environment as well as for them to enter a formal study of geometry, itself, and other areas like science and engineering. Also, Fey (1991) noted that all geometry instruction is to foster intellectual formation, that is, students should come to know what geometrical thinking is, what geometry is, what it studies and how it devises its method to do this study. He noted that geometrical thinking should not be identified as logical thinking for the latter is the domain of all mathematics. He further noted that the goal of geometry is to transmit important information about space that has been provided in the past and appear to be necessary in the years to come. That this necessity applies not only to preparing for further study of mathematics but for applying geometric knowledge to specific everyday affairs

Obioma (1985) expressed worries over the poor performance of students in mathematics when he discovered that deficiency profile of Junior Secondary School Students in mathematics were highest in geometry

and statistics. WAEC (1996) noted that the performance of candidates in mathematics continued to slide on the downward trend. That it appeared that many of the candidates did not have clear understanding of the subject matter. WAEC noted that the candidates were generally weak in areas of geometry and trigonometry. WAEC (2004) also reported that candidates performed poorly in Mathematics and also identified that candidates were weak in areas of geometry. WAEC attributed the weakness to among other reasons; inadequate coverage of the syllabuses, poor knowledge of the subject matter and inability of the candidates to show any firm grasp of the details needed to answer the questions. This scenario is corroborated by the report of the two (2) universities in the eastern Visayas Region during the Consultative Conference on February 10, 2021 that senior high graduates are weak in skills in Geometry and Trigonometry.

Virtual information and physical objects are deployed in regular teaching all over, and until recently, blending these two environments has been a very difficult task at best. Understanding the concepts of geometry and their three-dimensional (3-D) space is still considered a difficult subject area for some students. Therefore, a requirement of a learning innovation arises for learning geometry to overcome the problems faced while understanding geometry by students' (Amin, n.d.). In another vein, Shield and Kelly, (1999) in National Institute for Educational Development (NIED) (2010) found out that Mathematics contents were not fully covered. Emphasis is placed on few areas that involve numbers.

The Special Curricular Program in Science, Technology and Engineering is developed to cater students whose interests are in the fields of Science and Mathematics. To achieve its goals, the program enhances its basic education curriculum by offering additional science and mathematics subjects (Morados, 2020). Based on the recommendations of the State Universities in Region 8 during the Consultative Conference, Geometry and Trigonometry should be strengthened not only in STEM strand but in all strands in Senior High School to produce competent Senior High School graduates who were planning to enroll engineering, architecture, and other related courses in college. With this scenario, the proponent proposes that spherical trigonometry and analytic geometry" should be taught as a separate subject as the most possible intervention that can enhance the performance of the senior high school graduates.

Through this intervention, students would learn topics which are focused on Spherical Trigonometry and Analytic Geometry. These topics could hardly be covered in a semester based on the actual teaching experience of the teachers handling the subjects in STEM. Moreover, to strengthen student's skills in Mathematics, Geometry as a subject should be also offered as part of the intervention. In the same vein, it is regrettable, therefore, that in the contemporary times many students struggle with Mathematics and perform abysmally low in their final examinations in most jurisdictions. In Ghana, students' performance in Mathematics at the Senior High School has not been encouraging. Candidates are reported to exhibit poor understanding of Mathematical concepts and are unable to form the appropriate Mathematical models which could be tackled with the requisite skills" (Chief Examiner's Report, 2007). Moreover, Maasin City Division DMEA report shows that even though Mathematics has an average grade across grade levels of more than 75 (DMEA 2018 & 2019) but then an avenue for improvement is very wide. This scenario is substantiated by the division achievement test results conducted among grade 11 and 12 in School Year 2020-2021. The results show that Grades 11 and grade 12 learners only got an MPS of 51.46 and 56.02, respectively for Geometry and 45.60 and 44.68, respectively for Trigonometry which is an indication that they performed poorly in Mathematics.

In this context, the proponent was motivated to apply/employ possible intervention(s) to equip SHS students with the necessary skills in Geometry and Trigonometry by offering the subjects to improve their Mathematics performance while they are still in senior high in preparation of their journey to college.

### *1.1 Innovation, Intervention and Strategy*

After having conducted consultations with the senior high school Mathematics teachers during monitoring of schools with the issues and concerns of their actual teaching experiences raised, the proposed innovation to

address their concerns is to offer Math course such as Spherical Trigonometry and Analytical Geometry as an add on subjects to enrich senior high school learners. Geometry may be offered as an add on subject in the first semester and Trigonometry in the second semester in Grade 11. These subjects could be conducted at least twice a week.

*1.2 Action Research Questions*

This study generally aimed to determine if additional subjects in Mathematics in Senior High School could improve students' performance in Mathematics. Specifically, this study sought to answer the following questions.

- What is the level of Mathematics performance of Grade 11 learners before and after adding Math subjects?
- What is the level of Mathematics performance of Grade 12 learners before and after adding Math subjects?
- Is there a significant difference in the performance before and after the intervention to the respondents?

## 2. Action Research Methods

***Participants and/or other Sources of Data and Information -*** The participants to this intervention were the 455 Grade 11 and 226 Grade 12 senior high school students from Maasin City NHS, Maasin VHS, San Rafael Stand Alone Senior High School, Manhilo NHS, Dongon NHS, Nonok Norte NHS and Ibarra NHS. This research used pretest/posttest quasi-experimental design. The respondents took the additional subjects for Mathematics. Data were taken from the consultation conducted, teachers' interview, DMEA 2018 and 2019, findings and observations during school visits and the division achievement test results for senior high school.

***Data Gathering Methods -*** Researcher-made pre-test was conducted to assess students' performance in Mathematics, after reliability and validity are established. Crafted Learners Activity Sheets, after having undergone quality assurance by experts, were distributed to the respondents with limited face-to-face classes as the mode of teaching Trigonometry and Geometry. Students were monitored every now and then. The monitoring results and findings were inputted to the Mathematics teachers to guide them for smooth implementation of the intervention. After the implementation, a post-test was conducted. These two sets of data (Pre-Test and Post-Test) were summarized, compared and be the bases for interpretation. Thus, study used statistical tools such as frequency counts, mean, standard deviation, paired t-test for data analysis.

## 3. Discussion of Results and Reflection

Table 1 revealed that majority or 53% of the Grade 11 learners belonged to the poor level of performance. This means that learners in Grade 11 senior high school performed low in mathematics showing that they have no mastery yet of the expected competencies. This is supported by the figure in which 34% scored at Fair level and only 2 reached the excellent level implying that most learners are struggling with mathematical concepts and experiencing difficulty in working on the procedural computations or even in problem-solving aspects. In general, the pretest performance of Grade 11 learners is only at the Fair level where scores are ranging only between 9-17 which is below half of total score and passing score of 34.

Though students have encountered mathematical concepts already in Junior High School, it shows that there is no retention of those learnings especially without having a review or refresher. One factor is insufficient understanding or mastery of core areas such as geometry and trigonometry. This is supported by the study of Adhikari (2021) that learners in a secondary school in Nepal performed low in Mathematics, particularly in Trigonometry and Geometry because they failed to sustain retention from basic to complex concepts. Since the

curriculum is spiral where competencies in the said subjects are staggered from one grade to another with increasing complexity, learners are unable to sustain what they learn since there these subjects are not present in all grades. There is a grade where there is no geometry and trigonometry which give a tendency to forget and need to review back in order to have proper continuity and transition of concepts.

*3.1 Mathematics Performance among Grade 11 Learners*

**Table 1**

*Pretest and Posttest Results of G11 Learners*

| Level of Performance | Pretest | | Posttest | |
|---|---|---|---|---|
| | f | % | f | % |
| Excellent (36-45) | 2 | 0% | 50 | 11% |
| Very Good (27-35) | 19 | 4% | 95 | 21% |
| Good (18-26) | 40 | 9% | 100 | 22% |
| Fair (9-17) | 154 | 34% | 81 | 18% |
| Poor (0-8) | 240 | 53% | 129 | 28% |
| Total (N=455) | 455 | 100 | 455 | 100 |
| Mean | 9.13 | | 19.2 | |
| SD | 7.92 | | 12.33 | |
| Interpretation | FAIR | | GOOD | |

No. of items in the test = 45.

On the other hand, the posttest results showed an increase in quantity of learners in the Good, Very Good, and Excellent level. Frequency of learners at the Fair and Poor level decreased by almost half. Although the highest percentage of learners in the posttest is still as Poor level (28%), its frequency fell down dramatically by 25% which is already a big impact since most learners elevated their performance from fair towards good (22%), very good (21%) and excellent (11%) levels. On the average, their performance increased by a mean difference of 10 points which is good enough for learners to encounter the implemented intervention.

It is evident that learners' scores in geometry and trigonometry has improved during posttest. This could be attributed to the fact that the intervention was provided to the participants in which all learners were already engaged in various learning tasks that help them recall, reacquire, and master skills in geometry and trigonometry concepts and competencies. It further shows that teachers have facilitated well the delivery of the content and were able to impart understanding of the lessons to the learners using blended approaches. This implies that the intervention was carried out effectively to the learners which enable them to gain better performance in both subjects. This changes in scores reflect that teaching geometry and trigonometry is of big help for learners to enhance their knowledge and skills so that they can utilize it further when graduate in senior high school giving them readiness for course requiring those two subjects since these skills are also expected at the college level.

*3.2 Mathematics Performance among Grade 12 Learners*

In Grade 12 level, results in Table 2 reflected the pretest and posttest performance in Geometry and trigonometry. It can be seen that majority or 52% of the Grade 12 learners performed Good in the said subject before the intervention has been provided or has started. However, there are still a quantity of learners performing at Fair (29%) and Poor (12%) level which could be a good basis that the intervention to be given is relevant and necessary since these quantity of learners (N=91) are struggling or performing low with the said subjects and need much attention. This is substantiated by the study of Gloria (2015) that there are still a significant number of high school learners with low level of mathematical competence which significantly affect their performance in Trigonometry and Geometry.

It can be gleaned further that there are still number of learners who are performing well with the subjects since their score fall under Excellent (N=7) and Very Good (N=10) levels. This implies that these learners acquired mastery of skills about the subject since they already encountered them during their Junior High School

level. Thus, they have no difficulty to acquire further the skills when the intervention is provided to them along with other learners/participants. In general, the mean score in the pretest results is at the Fair level (M=17.85) which implies that the whole group started with varying levels of capacity where mostly are proficient and only few are already equipped with skills.

**Table 2**

*Pretest and Posttest Results of G12 Learners*

| Level of Performance | Pretest | | Posttest | |
|---|---|---|---|---|
| | f | % | f | % |
| Excellent (36-45) | 7 | 3% | 41 | 18% |
| Very Good (27-35) | 10 | 4% | 58 | 26% |
| Good (18-26) | 118 | 52% | 79 | 35% |
| Fair (9-17) | 65 | 29% | 43 | 19% |
| Poor (0-8) | 26 | 12% | 5 | 2% |
| Total(N=226) | 226 | 100 | 226 | 100 |
| Mean | 17.85 | | 25.35 | |
| SD | 6.93 | | 9.50 | |
| Interpretation | FAIR | | GOOD | |

No. of items in the test = 45.

On the other hand, posttest performance of the Grade 12 learners showed changes in scores. Most of them increased their level of performance. Looking specifically, majority of the learners are still at the Good level (35%) but the frequency of learners decreased since some of them improved their scores to higher level. The percentage of learners in the Very Good and Excellent levels increased by 15% leading to the decrease in the percentage of learners under Fair and Poor levels. These results showed that most of the learner's scores during the posttest have improved well after they were provided with the needed interventions. In fact, only 5 students remained at the poor level from 26 during the pretest.

Results imply that there is an improvement in the performance of Grade 12 students as an effect of the intervention provided. The intervention effectively helped the learners increase their level understanding as well as skills in performing the activities and problem sets in geometry and trigonometry. Most of the students were able to improve their capacity in working with the geometry and trigonometric concepts. Although there are other students who still remained at the fair and poor levels and still struggling with the subject, it shows that the interventions have helped them but not to high extent. Likewise, this level of mathematical abilities need more reinforcements and thereby, more activities and time for exercises are necessary to help them cope with the expected mastery of these concepts so that at least they can develop their conceptual learning of the content.

*3.3 Significance of Difference between Pretest and Posttest for Grade 11 & 12 Learners*

Table 3 revealed that there is significant difference shown in the performance of Grade 11 learners before and after the intervention. This is indicated by the p-value (.000) which is less than the significance level. This implies that the increase in scores significantly validates the improvement of performance in Geometry and Trigonometry among the learners. It can be deduced that the intervention provided has effectively equip the learners with the needed proficiency in skills in terms of how to deal, work, and apply on useful concepts in Geometry and Trigonometry. Thus, with the offering of Geometry and Trigonometry subjects, learners could do more in Mathematics.

**Table 3**

*Paired t-test results between Pretest & Posttest*

| Grade Levels | Variables | Mean | N | SD | SE Mean | df | t | Sig. | Interpretation |
|---|---|---|---|---|---|---|---|---|---|
| G11 | Pretest to Posttest | 10.07 | 455 | 8.650 | .41 | 454 | 24.85 | .000* | Significant |
| G12 | Pretest to Posttest | 7.50 | 226 | 5.298 | .35 | 225 | 21.28 | .000* | Significant |

*result is significant at p<.05 (Sig. level at ά=5%).

*3.4 GenMath Performance among Grade 11 Learners*

Results reflected in Table 4 revealed that majority or 41% of the Grade 11 learners started the intervention with a good level of performance. This means that learners in Grade 11 senior high school performed at the average level to the extent they already have a sort of prior knowledge about the subject. However, 34% of the learners are at the Fair level of performance implying that these students have less grasp of the topic.

**Table 4**

*Pretest and Posttest Results of G11 Learners*

| Level of Performance | Pretest | | Posttest | |
|---|---|---|---|---|
| | f | % | f | % |
| Excellent (36-45) | 9 | 2% | 121 | 28% |
| Very Good (27-35) | 92 | 22% | 295 | 69% |
| Good (18-26) | 174 | 41% | 10 | 2% |
| Fair (9-17) | 147 | 34% | 0 | 0% |
| Poor (0-8) | 5 | 1% | 1 | 0% |
| Total(N=455) | 455 | 100 | 455 | 100 |
| Mean | 21.06 | | 33.22 | |
| SD | 6.94 | | 3.96 | |
| Interpretation | GOOD | | VERY GOOD | |

No. of items in the test = 45.

In the posttest it can be observed that there is an increase in their performance since majority or 69% of learner improved their performance to the very good level and none of them belonged to the fair and poor level. Hence, it shows that there is an improvement in their learning with the general mathematics due to the inclusion of learning Geometry and Trigonometry.

*3.5 GenMath Performance among Grade 12 Learners*

It can be observed from the results in Table 5 that students on the average performed in the same level which is very good. However, there is a difference in their mean score which reflected an increase of 4 points. This implies that students before the intervention already have a better background of the subject, and this was enhanced well after the intervention. This is because these Grade 12 students already underwent mathematics during their Grade 11 hence, they already have a good grasp of the subject matter.

**Table 5**

*Pretest and Posttest Results of G12 Learners*

| Level of Performance | Pretest | | Posttest | |
|---|---|---|---|---|
| | f | % | f | % |
| Excellent (36-45) | 7 | 3% | 76 | 25% |
| Very Good (27-35) | 115 | 51% | 150 | 66% |
| Good (18-26) | 102 | 45% | 0 | 0% |
| Fair (9-17) | 3 | 1% | 0 | 0% |
| Poor (0-8) | 0 | 0% | 0 | 0% |
| Total(N=226) | 226 | 100% | 226 | 100% |
| Mean | 29.53 | | 33.62 | |
| SD | 6.67 | | 3.29 | |
| Interpretation | VERY GOOD | | VERY GOOD | |

No. of items in the test = 45.

*3.6 Significance of Difference between Pretest and Posttest for Grades 11 & 12 Learners*

Table 6 revealed that there is significant difference shown in the performance of Grade 11and G12 learners before and after the intervention. This is indicated by the p-value (.000) which is less than the significance level. This implies that the increase in scores significantly confirms the increase in scores from pretest to posttest performance in General Mathematics among the learners. It implies that the inclusion of Geometry and

Trigonometry in General Mathematics contributed to the performance of learners. Furthermore, the intervention provided has effectively equipped the learners with skills to enable them to demonstrate learning across competencies of General Mathematics.

**Table 6**

*Paired t-test results between Pretest & Posttest*

| Grade Levels | Variables | Mean | N | SD | SE Mean | df | t | Sig. | Interpretation |
|---|---|---|---|---|---|---|---|---|---|
| G11 | Pretest to Posttest | 12.16 | 455 | 5.57000 | .269 | 426 | 45.06 | .000* | Significant |
| G12 | Pretest to Posttest | 4.088 | 226 | 4.57000 | .217 | 442 | 18.84 | .000* | Significant |

*result is significant at p<.05 (Sig. level at ά=5%).

From the results in this study, the researcher, realized how important is to engage learners in Geometry and Trigonometry at the Senior High Level. This addresses the issues in which most SHS completers are way behind with entrance examinations in courses that require much of mathematical knowledge and skills because SHS today do not deal much of Mathematics since most concepts are taught already in Junior High School. As learners transitioned to SHS, their learnings are forgotten because they are not anymore considered in most subjects in SHS program. The General Mathematics core subject is simply a summary of what was dealt entirely in JHS Mathematics yet most learners or JHS completers have poor retention. Thus, the offering Geometry and Trigonometry, which are higher mathematical concepts are timely and relevant since these are subjects that would prepare learners as they transitioned to college level. As stressed by Yang and Sianturi (2017) and Fiallo and Gutirrez (2017), Trigonometry and Geometry are an important section in Secondary School Mathematics Curricula because they link algebraic, geometric, and graphical reasoning.

## 4. Conclusion

Inclusion of Geometry and Trigonometry in teaching Mathematics among senior high school learners could improve their performance.

***Recommendation -*** In the light of the results of the study, it is highly suggested that this serves as an impetus for curriculum developers and other stakeholders to reflect and possibly make alterations in the SHS Math curriculum which would include Trigonometry and Geometry. Moreover, it is high time to revisit the K to 12 Basic Education, especially the Senior High School Mathematics offering. DepEd High officials need to realize that there is a strong reason to modify/revise the present curriculum so that learners would be equipped with strong foundation of Mathematics as they enter the real world of work and their chosen career. Moreover, General Mathematics competencies should be decongested to be more realistic in its implementation.

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