English and Mathematics: Determinants of Physics Achievement among Public High School Seniors in Naga City

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Abstract – *This evaluative and relational study determined the influence of English and Mathematics on the Physics achievement of public high school senior students in Naga City, Philippines. Results showed that the students had an average achievement level in Speaking, Reading, Literature and Grammar. The overall achievement level in Advanced Algebra, Trigonometry and Statistics was average. The overall achievement level in Optics and Waves, Nuclear Physics and Mechanics was average. There was a significant positive relationship between English and Physics achievement, and between Mathematics and Physics Achievement. Reading, Literature and Grammar were the areas in English that significantly influenced Physics achievement. In Mathematics, Advanced Algebra and Trigonometry significantly influenced Physics achievement. The students' achievement between English and Physics had no significant difference at 1% level but significantly different at 5% level. Mathematics and Physics achievement had no significant difference at 1% and 5% levels. There was no significant difference between schools C and D; A and C; and schools B and C at 5% and 1% levels. However, the achievement level between schools A and B, B and D, and schools A and D were significantly different at 1% level.*

Keywords: Determinants, English, Mathematics and Physics Achievement

I. INTRODUCTION

Science, may it be in any form, has a key role to national economic prosperity. It has been a universal reality that no nation can advance without foregoing and utilizing the outcome of scientific researches or their applications in the industries, military, medicine and in the other aspects of human existence, hence, it is applied in one's practical life situations.

Budhan (2005) had said that within the context of globalization, the country's ability to achieve and maintain a high standard of living would be dependent on the extent to which it could harness science and technology. He argued that it was the ability of the citizenry to embrace science and technology that would ensure that the economy of the country remained internationally competitive. He further emphasized that:

> *to enhance the international competitiveness of the country, it is therefore critical for everyone to promote science and technology in the education system. Science and technology are at the heart of the development of human societies.*

But it has been the dilemma in the Philippine education setting in terms of how students perform in science and how their knowledge and skills are utilized in developing newer technologies to fair with neighboring countries and the rest of the world.

The Philippines is far beyond in achieving quality education, as cited in the recent UNESCO report that ranked the Philippines 74th in the Education Development Index, falling below Mongolia, 61st; Vietnam, 65th; Indonesia, 58th; and China, 38th (UNESCO, 2008).

Science is taught in Japanese, Chinese, Korean and the native languages of all those who topped the Trends International Mathematics and Science Study (TIMMS) from 1995 to 2003. Thus, the role and function that language serves for students when they speak and reason about physical ideas and phenomena are also crucial in their achievement in science.

On the other hand, Physics, being the most quantitative of all the sciences, employs many mathematical skills to prove and quantify the different physical laws and principles. Among the courses taught in most schools, Physics is a subject heavily dependent on mathematical skills (Basson, 2002). Because of this, Mathematics has become inevitable in Physics instruction and the practical applications of its concepts, thus, Mathematics is now considered the tool and language of Physics.Indeed, students' communication and mathematical skills may affect their achievement in Physics.

According to the National Statistical Coordination Board (2008) of the Philippines, the recent National Achievement Test (NAT) results reflected a declining education performance. The overall achievement rate of Fourth Year high school students were worse off with only 44.3% decreasing by two percentage points from the previous year. Scores in all subject areas in the secondary level went down by about one to six percentage points, and Science was the least of the competencies, an alarming situation that should be seriously addressed by the educators of the country.

This study was undertaken to demonstrate how Physics achievement level can be influenced by the achievement level in the areas of English and Mathematics. The results of this

study may be of help to the curriculum planners of the Department of Education in the division and national levels to identify the appropriate measures needed to address this problem.

This study was primarily anchored on Gardner's Theory of Multiple Intelligences (MI) which states that a child is born not only with one aspect of intelligence but also with the other aspects of intelligence, such that, the development of one intelligence may permeate the development of the other. Thus, learning any subject area which includes science may be greatly affected by the development of the intelligences. This may be observed in a person who developed logical and mathematical skills after developing his linguistic intelligence.

II. OBJECTIVES OF THE STUDY

This evaluative and relational study determined the influence of English and Mathematics on the Physics achievement of public high school senior students.

The specific objectives were to: assess the achievement level of students in English (along speaking, grammar, reading and literature), Mathematics (along Advanced Algebra, Trigonometry and Statistics) and Physics (along Optics and Waves, Nuclear Physics, and Mechanics) based on the results of the Division Achievement Test; determine whether there is a significant relationship betweenEnglish and Physics achievement; and between Mathematics and Physics achievement; determine the extent in which the achievement in English and Mathematics influence Physics achievement; compare the achievement among the three subjects and among schools.

III. MATERIALS AND METHODS

This study utilized the descriptive-evaluative and correlational methods of research in evaluating the results of the DAT. The mean scores of the students for each area were taken to determine their achievement, which were classified into: very high (81%-100%), high (61%-80.99%), average (41%-60.99), low (21%-40.99%) and very low (1-20.99%).

To determine the significant correlation between English and Physics achievement, and between Mathematics and Physics achievement, the correlation coefficient was computed using the Pearson's Product Moment and compared them to the critical values of r. Regression analysis (R^2) was used to determine the extent to which achievement in English and Mathematics influenced Physics achievement. Analysis of the Variance (ANOVA) was used to the achievement among the three subjects and among schools.

IV. RESULTS AND DISCUSSION

Achievement Level. The mean scores of the students in English (along speaking, grammar, reading, and literature), Mathematics (along Advanced Algebra, Trigonometry and Statistics) and Physics (along Optics and Waves, Nuclear Physics, and Mechanics) were taken to determine their achievement, which were classified into: very high (81%-100%), high (61%-80.99%), average (41%-60.99), low (21%-40.99%) and very low (1-20.99%).

English Achievement Level. The results revealed that the overall achievement level of the students in the different areas of English was average. This meant that the students were average in identifying similar sounds or rhymes; proper syllabication; uses of expressions and finding the correct meaning of a word or phrase; identifying the speaker; structural analysis, correct usage of verbs and its forms and types of phrases; highlighting; and identifying the function of a verbal; choosing words that best complete the sentences; logical organization of ideas; applying figurative devices; identifying the literary form, tone, mood and point of view of a writer; identifying the main idea and the author's purpose in a given literature; in noting details; getting the main idea; cause and effect; inferring; synonym; identifying word references, figurative languages, character traits, point of view, identifying theme and author's purpose and outlining.

However, considering the achievement level in every area, in Reading, school A was high, while schools B, C and D were average. In Literature, school A was high, while schools B and C were average and school D was low. In grammar, school B was high while the rest of the schools were average.

School D which ranked 4th in the overall achievement in English was low in literature. This area together with Grammar, were the two of the least learned areas in English which ranked 3rd and 4th, respectively. These areas necessitate exercises and activities that involve literary and other related materials. It can be noted that school D was newly-organized and it lacks enough academic resources which can prepare and aid the students in learning the competencies.

The other factors that might have contributed to the low achievement of school D in literature include the students' readiness. This can be explained by Krashen's Language Acquisition Theory (1988). In this theory, language acquisition was defined as the process by which the language capability develops in a human. According to the proponent, first language acquisition concerns the development of language in children, while second language acquisition focuses on language development in adults. Those who were not able to develop the prerequisite language skills cannot advance to higher language skills. In addition, according to the Literary Theory (Nash, 1983), particularly on Literary Language, the ordinary language acquired and developed by a person or a student in his day-to-day activities is not only useful in the communication process itself, but also in understanding and interpreting Literature.

Language and communication are practical skills that can only be learned through constant use. As cited by Power (2005), English has become an inevitable part of human life, hence, just like computers, it has been one of the basic needs to survive.

Research showed that Filipino children's language skills develop when the child is motivated to communicate in English; when there are diverse opportunities to use the language; and when there is present in the learning environment a good role model of the target language who can understand one of the child's languages which can be provided primarily by teachers who are capable of motivating and

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delivering the needs of the students in achieving higher in the different areas in English (Licuanan, 2007).

Mathematics Achievement Level. The overall achievement level of the students in Advanced Algebra, Trigonometry, and Statistics was average. Accordingly, the students were average in applying the rules for set of ordered pairs of a function; distinguishing and solving problems involving function of given sets of data; solving for the x and y intercepts of a linear function; solving for the slope of a line; finding the equation of a line; applying linear function in a worded-problem; writing a quadratic function in a standard form; identifying the factor of a quadratic function; solving the vertex and equation of a quadratic function; applying quadratic function in a worded-problem; evaluating a logarithmic function; solving problems involving exponential function particularly growth and decay;converting degree to radian for a circular function; solving for the reference angle and the arc of a circular function; finding the side of a right triangle and the values of sine and cosine of a trigonometric function; solving the mean median and mode for ungrouped and grouped data, interpreting a frequency distribution for ungrouped data and solving for the standard deviation.

However, taking the individual achievement level in every school, school D was low. These findings implied that the students found difficulties in understanding and applying basic and advanced concepts and properties of numbers, measurement, geometry, statistics and data analysis, probability, function and algebra. Furthermore, students might have encountered difficulties in using varied strategies for solving problems and in adapting to the methodologies employed by the teachers.

Since the rest of the schools were average in Mathematics, teacher's instruction and methodology in school D should be considered as factors that might have influenced these results, or the students themselves do not possess the necessary skills to advance along the learning competencies in all the areas in Mathematics.

These findings were parallel to Gardner's Theory of Multiple-Intelligences (2000) which believed that the development of high order thinking skills ascends from one skill to another. Given the right conditions and learning approach, the students will progress from a lower to a higher skill - from computational to analytical skills. Thus, the analytical skills needed in learning the competencies in Mathematics and Physics could only be acquired after the students have progressed from his knowledge and comprehension skills. But the latter could only be developed if one is proficient with the language that he used.

Though this study was mainly focused on the correlation between English and Mathematics achievement to Physics' achievement, it does not set aside other factors that might have affected the actual learning process. Broder (2004) found that the role of motivational processes, personality factors, the use of learning strategies and scholastic aptitude in academic achievement correlated significantly with GPA.

Physics Achievement Level. The overall achievement level of the students in all the areas of Physics was average.These results implied that the students were average in relating energy, technology and society; applying the different properties of light; identifying and analyzing the uses of the different kinds of mirrors and lenses; describing the different images formed by the use of mirrors and lenses; explaining the property of magnetism; tracing energy transformations; practical applications ofconcepts in electricity; solving the rate of motion of a body in terms of speed, velocity and acceleration; applying the laws of motion, particularly the law of interaction; solving for momentum, force, energy or work done and its unit; analyzing the flow of thermal energy; recognizing the different nuclear processes and reactions; distinguishing the key scientists who made remarkable contributions in the field of Nuclear Physics and identifying examples of radioisotopes and the different types of nuclear radiation they emit.

However, taking account the individual results of every school, the achievement level of the students in Optics and Waves for school B was high, while the rest of the schools were average. In Nuclear Physics, schools A, C and D had an average achievement level while school B was low. In Mechanics, schools B and C had an average achievement level while the two other schools were low.

School B got low in Nuclear Physics. The students lack the necessary skills in recognizing the different nuclear processes and reactions; distinguishing the key scientists who made remarkable contributions in the field of Nuclear Physics; and in identifying examples of radioisotopes and the different types of nuclear radiation they emit.

Moreover, the students from school D were lowest and ranked 4th in the overall achievement in Physics. School D together with school A was low in Mechanics, the least learned area of Physics. It is important to note that this area requires knowledge in Advanced Algebra. But since they also performed low in this area, students experienced difficulties in Mechanics which consequently pulled down the overall Physics achievement of schools A and D. This premise was supported by the study conducted by Hudson and Rottmann (2004). They presented results stating that prior mathematical ability is a primary influence on performance in an introductory, pre-professional Physics course.

Significant Relationship. The mean scores in the achievement test in the different areas of English and Mathematics were correlated to the mean scores in Physics using the Pearson's Product-Moment Correlation.

English and Physics. The obtained overall correlation coefficients (r_{xy}) between English along reading, Literature, Grammar and Speaking, and Physic were higher than the critical values of r at 0.01 and 0.05 levels of significance. These results implied that these areas in English were positively correlated with Physics. Therefore, the hypothesis that there is a significant relationship between English and Physics achievement was accepted. The results also indicated that if a student is good in English he is also good in Physics. The learning competencies in English are needed to facilitate effective understanding of Physics.

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These findings were supported by the study of Lerio (2006). He found out that those who were good in English were also good in Mathematics. On the other hand, those who were poor in English were also poor in Mathematics. English is also the medium of instruction in Physics and highly mathematical; hence English was significantly related to Physics. He also stressed that the application of Gardner's MI theory would provide a deeper understanding of the interconnection of the development of one skill with another, from verbal linguistics to logical-analytical intelligences.

The significant relationship between English and Physics achievement was further illustrated by Lemke (2005). He stated that the primary activity that students encounter and participate in, in a Physics course, was representation. The use of language is one of the many ways of representation. Therefore, the first ability that the students have to develop is the ability to represent ideas and physical processes in different ways and to move between representations which can only happen if one is equipped with enough communication skills.

Mathematics and Physics. The obtained over-all correlation coefficients (r_{xy}) implied a very high correlation between Trigonometry and Physics; and moderate correlation between Advanced Algebra and Physics and between Statistics and Physics.

Therefore, the hypothesis that there is a significant relationship between Mathematics and Physics achievement was accepted. These results suggested that these areas in Mathematics were needed to develop the skills and learning competencies in Physics. As such, the students' success in Mathematics will directly affect the achievement in Physics or the students must be proficient in the different competencies in Mathematics to fully understand Physics.

The close relationship between the two subjects was also cited by Czerniak et al (2005) in their literature review of science and Mathematics integration. They said that Mathematics and Physics have been closely intertwined since ancient times. The development of the different fields in Physics can be attributed to the vital role played by Mathematics.

Realizing the direct relationship between Mathematics and Physics achievement, Steen (2003) considered employing scientific examples and methods thoroughly in Mathematics instruction, taking necessary steps to coordinate the curricula of the two subjects. This too would have great benefit both for Mathematics and for science, but in uncommon ways. For Mathematics, it would reinforce the perspective of investigation, exploration and experimentation. For science, it would help underscore the importance of careful data analysis, logical thinking and modeling as part of the scientific method.

This process of integration that can be established could benefit not only prospective school teachers but also the students. After all, Mathematics is indeed a tool in the applications of the concepts in the physical world; hence, it was proven that Mathematics achievement was positively correlated with the Physics achievement of the students.

Significant_Influence. The mean scores of the students in English (along speaking, grammar, reading, and literature) and Mathematics (along Advanced Algebra, Trigonometry and Statistics) were tested using Regression Analysis to determine their significant influence in the Physics achievement of the students.

The coefficient of determination (R^2) value of 0.627 in Grammar, 0.754 in Reading and 0.748 in Literature indicated that in determining Physics achievement 62.7%, 75.4% and 74.8% of the variance in Physics achievement can be accounted to or explained by these areas. This also suggested that these areas would affect the variability in the Physics achievement of the students at 62.7%, 75.4% and 74.8%, respectively.

The unstandardized partial regression coefficients inthe equation for the different areas in English were -2.889in Speaking, 0.793 in Grammar, 0.992 in Reading, and 0.816 in Literature. The English achievement along Grammar, Reading and Literature showed positive values which would mean a positive correlation to Physics achievement. This meant that for every additional score in these areas, the probability of getting the correct answer in the Physics achievement test went up by a factor of 0.793 in Grammar, 0.992 in Reading, and 0.816 in Literature. This further indicated that for every unit of increase in the achievement level of the students in these areas, it is highly probable that their achievement level in Physics will also increase by 0.992, 0.816, and 0.793 units. The more proficient the students are in these areas, the higher will be the predicted achievement level in Physics.

The corresponding t-test of the partial regression coefficient at 0.01 level of significance revealed that the computed t-values of 2.478 in Reading, 2.439 in Literature, and 1.834 in Grammar were higher than the tabular values of 0.208, 0.132, and 0.135, respectively, accepting the alternative hypothesis that these areas significantly influenced Physics achievement, hence, they could also predict the Physics achievement of the students.

Consistently, Reading was the number one variable that has significantly influenced the Physics achievement of the students. On the other hand, Speaking has no significant relationship with Physics achievement. These results can be ascribed to the fact that while English is the medium of instruction in Physics, the different concepts, including the worded-problems in Physics require the fundamental skills in reading and not speaking.

Mathematics and Physics. The coefficient of determination (R^2) value of 0.413 in Advanced Algebra and 0.997 in Trigonometry indicated that in determining Physics achievement 41.3% and 99.7% of the variance in Physics achievement can be accounted or explained by explanatory variables: Advanced Algebra and Trigonometry. This also suggested that the variability in the Physics achievement of the students would be affected at a rate of 41.3% in Advanced Algebra and 99.7% in Trigonometry.

The unstandardized partial regression coefficients in the equation for the different areas in Mathematics were 0.870 in Advanced Algebra, 2.443 in Trigonometry, and-0.549 in Statistics. The Mathematics achievement along Advanced Algebra and Trigonometry showed positive values whichmeant a positive correlation to Physics achievement. Therefore, for

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every additional score in these areas, the probability of getting the correct answer in the Physics achievement test went up by a factor of 0.870 in Advanced Algebra and 2.443 in Trigonometry. The positive correlation of Advanced Algebra and Trigonometry to Physics achievement indicated the direction of change, that every unit increase in these areas will have a corresponding increase in the Physics achievement of the students. The more proficient the students are in these areas, the higher will be their predicted achievement level in Physics.

The corresponding t-testof the partial regression coefficient at 0.01 level of significance revealed that the computed t-values of 1.815 in Advanced Algebra and 24.170 in Trigonometry were higher than the tabular values of 0.358 and 0.002, accepting the alternative hypothesis that these areas significantly influenced Physics achievement; hence, they could also predict the Physics achievement of the students.

These results of the multiple linear regression analysis proved that these areas in Mathematics, particularly, Trigonometry and Advanced Algebra were factors that directly affected the Physics achievement of the students. These results were also supported by Spearman's Two Factor Theory (Aspinwall, 2000) where it can be concluded that intelligence could be distinguished into a general factor and specific factor, in which the general factor represented by the different areas greatly affect the other specific factor, represented by the students' achievement in learning Physics. These findings implied that the different areas in Mathematics were key competencies required for a good Physics achievement of the students.

Significant Difference. To determine the significant difference among the subjects and among the schools, t-test was used. The computed t-value was compared with the tabular t-values of 3.182 at 5% and 5.841 at 1% levels of significance.

Among the subjects. There was no significant difference in the achievement levels in English. Mathematics and Physics at 0.01 level of significance, hence they are positively correlated, rejecting the alternative hypothesis. This is in line with the results of the linear regression where the areas in English and Mathematics were significantly correlated and influenced the Physics achievement of the students.

Frykholm and Meyer (2003) found out that in terms of the content structure, the relationship seems to be asymmetric between these subjects. Unlike the Mathematics teacher who can choose to avoid science, the science teacher is not able to cover most topics without calling on mathematical concepts and skills, and not using Englishas the medium of instruction. The unbalanced structure between the subjects' curricula may result to low or high student achievement.

Among the Schools. There was no significant difference in the achievement levels of the schools in English.This meant that the achievement levels in these schools were significantly related to each other, rejecting the alternative hypothesis. This meant that each school is faring well with one another in terms of their English achievement.

However, there was a significantdifference in the achievement levels of the schools in Mathematics and Physics. The low achievement of school D in Mathematics and Physics might have resultedto the significant difference between this school and the other schools. Furthermore, the significant difference might have been affected by the environment, teaching strategies and approaches and individual differences of the students. This is supported by the Theory of Multiple Causality (Williams, 2003) where the resulting behavior cannot be simply accounted to one cause only, instead, there are interdependent variables or factors interacting with each other that might have contributed or led to a particular event or behavior. In addition, other approaches can also be considered to provide an adequate contextual framework that can enhance the learning process.

Taylor (2007) found out that students' achievement would improve when the curriculum was restructured through strengthening the relationship among science, Mathematics and English both in terms of how the formal curriculum was expressed and day-to-day teaching and learning practices. Language-focused activities could either be incorporated into the science or Mathematics instruction or students may work on parallel activities. The separate language-based units of work, using science and Mathematics content, could be taught as part of the English language integrated with content - teaching curriculum.

V. CONCLUSIONS AND RECOMMENDATIONS

Academic program developers in the division level must ascertain a higher standard and quality education, and ensure the validity and reliability of the achievement test results. On the other hand, particular schools identified with low achievement level in the different learning competencies must restructure their strategies in teaching to ensure that these competencies are developed among the students.

The teachers must identify students with less-learned competencies in Mathematics who need remediation and provide enrichment activities for those who have high achievement level.

Teachers must employ varied learning opportunities for the students particularly in the identified less-developed competencies. These include; outdoor Physics, practical work activities, cooperative learning, computer-aided instruction, manipulative devices, games and other interactive instructions and activities.

Although each subject follows a particular set of competencies, educators and managers, at least, in the division and school levels should plan and initiate an integration of the three (3) key areas to maximize academic development for the students. English literature should include selections in Physics; likewise, worded-problems in Mathematics should cover problems in Physics.

The different public high schools must consider benchmarking to assess how they fair with one another in terms of academic programs, strategies and methodologies, teacher instruction and other related activities.

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