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**Research Article**

## Performance Assessment of the First Year Engineering Students using Force and Motion Conceptual Evaluation (FMCE)


Exedy C. Lampara*

College of Engineering, Architecture, and Technology, Rizal Technological University, Mandaluyong City 1550, Philippines



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**Corresponding author:*
E-mail:
elampara@rtu.edu.ph



**ABSTRACT**

The admission of non-STEM graduates to engineering programs creates an opportunity to determine if the Senior High School strand does really dictate the performance of students. This study administered the Force and Motion Conceptual Evaluation (FMCE) to the first-year engineering students to determine if STEM graduates perform better than non-STEM graduates. The FMCE was administered to six hundred-seven (n = 607) first year engineering students of a state-run university in the Philippines, school year 2019-2020 and 2020-2021. The results reveal that there is no significant difference between the mean scores obtained by the STEM and non-STEM graduates (p = 0.912) in the FMCE. It was noted that the students who graduated from private and public high schools have similar performance (p = 0.242). Nevertheless, there is an urban-rural gap in performance among the respondents, where students who graduated from schools in cities have better performance than those who graduated from rural schools (p = 0.019). Finally, in the field dominated by male, the results suggest that female students are at par with male student students (p = 0.123) and both have statistically the same level of confidence with their answers (p = 0.176).



***Keywords:*** *Engineering students, STEM, Urban-Rural Gap, FMCE*


## Introduction

The implementation of the K-12 curriculum has changed the Philippine educational landscape. After completing junior high school level, the students are free to choose among the strands or tracks in senior high school level according to their preferred degrees in college and interests. Students can choose which strand to enroll such as Science, Technology, Engineering, and Mathematics (STEM); Accountancy, Business, and Management (ABM); Humanities and Social Sciences (HUMSS); General Academic Strand (GAS); and Technology-Vocational-Livelihood (TVL), and other strands.

The Philippines' first batch of K-12 curriculum graduated last 2018 and are expected to be empowered citizens who have learned, have


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the capability to engage in autonomous, creative, and critical thinking. According to the Department of Education's Science Curriculum Guide, the K-12 graduates must demonstrate scientific inquiry, understand and apply scientific knowledge, and develop and demonstrate scientific attitudes and values.

In the tertiary level, the engineering programs preferred students who are STEM graduates. These students are expected to have mathematical and scientific skills to be used in university level subjects. These students are equipped and taught advanced mathematics and sciences during their senior high school (SHS) years. While this is logical, however, it is prejudicial since other non-STEM graduates also wanted to take engineering programs. According to a report (Uy & Martinez, 2019), several Philippine schools cannot offer STEM programs because of the lack of classrooms and facilities, limited teachers, and limited student enrollment. This means that students, even those who wanted to take STEM degrees, opted to enroll in other academic tracks because their school does not offer STEM strand. Transferring to another school offering a STEM program is not also feasible because of the distance from their home, financial support, and other constraints.

The Commission on Higher Education (CHED) of the Philippines addressed this unequal opportunity among K-12 graduates by allowing non-STEM graduates to enroll in the engineering programs. According to CHED Memorandum Order No. 86 series of 2017, the Higher Education Institutions (HEIs) are directed to provide the non-STEM graduates a bridging program prior to admission to the engineering programs. This allows non-STEM graduates such as ABM and HUMSS to take engineering degrees provided that they passed the bridging program. However, in the class with different SHS strands, does the strand matter?

One study revealed that, in the health science programs, the STEM graduates adjusted and academically performed well compared to other students who are graduates of different strands (Alipio, 2020). In 2020, a study reported that STEM and ABM groups performed above the average in the Scholastic Abilities Test for Adults (SATA), while the HUMSS and GAS groups obtained average scores, and the TVL group performed below the average (Almerino et al., 2020).

In a highly specialized course in engineering such as Physics, students who developed mathematical and spatial skills have the advantage. STEM graduates have the upper hand compared with the other SHS strands because they took science and mathematics classes in their SHS years. They were trained with advanced concepts and skills in sciences. However, no one can deny the fact that student performance is not only based on the strand they graduated from.

Thus, this study aims to assess the K-12 graduates taking up engineering programs. In particular, the study wants to determine if the SHS strand affects the performance of students. The study also investigates several factors including type of school, location of school, sex, and level confidence of their answers.

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## Materials and methods

### *Research Design*

The study utilized cross-sectional research design. The respondents are first year engineering students of Rizal Technological University in Mandaluyong City, Philippines. All of them are K-12 graduates and are first takers of Physics for Engineers – 1 class, enrolled in engineering programs such as mechanical civil, electronics and communication, electrical, computer, industrial, and instrumentation and control. The assessment was administered at the beginning of the semester. The study was implemented in the academic year 2019-2020 and 2020-2021.

### *Assessment Tool and Analyses*

This study assesses the understanding and confidence in Physics of K-12 graduates using Force and Motion Conceptual Evaluation (FMCE), an assessment tool developed by Thornton and Sokoloff (Thornton & Sokoloff, 1998). Only forty-three (43) out of forty-seven (47) questions were utilized in this study. The FMCE has been used to evaluate Physics instruction and is a valid and reliable tool to measure the concepts of force and motion (Ramlo, 2008).

39-A. Two students sit in identical officer chairs facing each other. Bob has a mass of 95kg, while Jim has a mass of 77kg. Bob places his bare feet on Jim's knees, as shown. Bob then suddenly pushes outward with his feet, causing both chairs to move. In this situation, while Bob's feet are in contact with Jim's knees,


a. Neither student exerts a force on the other
b. Bob exerts a force on Jim, but Jim doesn't exert any force on Bob
c. Each student exerts a force on the other, but Jim exerts the larger force
d. Each student exerts a force on the other, but Bob exerts the larger force
e. Each student exerts the same amount of force on the other
f. None of these answers is correct

For item 39,
a. I am sure that my answer is correct
b. I think that my answer is correct
c. I think that my answer is incorrect
d. I am sure that my answer is incorrect and simply guessing

*Figure 1. Sample question in the assessment tool*

*Table 1. 4-Point Likert Scale Verbal Interpretation*

| ***Range of Weighted Mean*** | ***Verbal Interpretation*** |
|---|---|
| 1.00 – 1.49 | Not Very Confident |
| 1.50 – 2.49 | Not Confident |
| 2.50 – 3.49 | Confident |
| 3.50 – 4.00 | Very Confident |

The assessment tool is similar to two-tier multiple choice, that is, after answering the question, the respondents will be asked if they are sure and confident with their answer. The stem question aims to know their understanding in Physics while the second tier intends to know whether they are confident with their answer or not. A sample question is shown in Fig. 1.

The confidence of the students on their answers were interpreted as depicted in Table 1. The mean confidence range 1.00-1.49,1.50-2.49, 2.50-3.49, 3.50-4.00 were interpreted as they are not very confident, not confident, confident, and very confident on their answers, respectively. For the description analysis, the frequency, percentage, mean, and standard deviation were utilized. The Mann-Whitney U test was used to compare the means of the groups and to determine if there is significant difference.

## Results

The summary of student's scores and confidence with respect to strand, school, location of the school, and sex is shown in Table 2. There are 607 respondents in this study, 332 are STEM graduates (54.70%) while the remaining 275 respondents (45.30%) are non-STEM graduates. The STEM graduates obtained a slightly higher mean score ($\bar{x}$ = 8.16, SD = 4.26) in the assessment as compared to non-STEM mean score ($\bar{x}$ = 7.92, SD = 3.62). They also have slightly higher mean confidence on their answers (MC = 3.03) than non-STEM graduates (MC = 3.00). When these means are compared using Mann-Whitney U test, the results suggest that the difference between the mean scores (p = 0.912) and mean confidence level (p = 0.529) of the two groups are not significant, as depicted in Table 3.

*Table 2. Differences in the scores of students across variables*

| | | *f* | % | $\bar{x}$ | *SD* | *Mean Confidence (MC)* | *Verbal Interpretation* |
|---|---|---|---|---|---|---|---|
| Strand | STEM | 333 | 54.70 | 8.16 | 4.26 | 3.03 | Confident |
| | Non-STEM | 275 | 45.30 | 7.92 | 3.62 | 3.00 | Confident |
| Type of School | Private | 287 | 47.28 | 7.84 | 3.84 | 3.00 | Confident |
| | Public | 320 | 52.72 | 8.24 | 4.10 | 3.03 | Confident |
| Location of School | Urban | 535 | 88.14 | 8.21 | 4.11 | 3.03 | Confident |
| | Rural | 72 | 11.86 | 6.93 | 2.66 | 2.88 | Confident |
| Sex | Male | 408 | 67.22 | 7.73 | 3.28 | 3.04 | Confident |
| | Female | 199 | 32.78 | 8.71 | 5.07 | 2.97 | Confident |

*Table 3. Comparison of mean scores and confidence level of the respondents*

| | | *Score* | | *Confidence* | |
|---|---|---|---|---|---|
| | | *Mean Rank* | *p-value* | *Mean Rank* | *p-value* |
| Strand | STEM | 303.29 | 0.912 | 308.05 | 0.529 |
| | Non-STEM | 304.86 | | 299.11 | |
| Type of School | Private | 295.24 | 0.242 | 296.89 | 0.340 |
| | Public | 311.85 | | 310.38 | |
| Location of School | Urban | 310.10 | 0.019 | 310.72 | 0.009 |
| | Rural | 258.67 | | 254.08 | |
| Sex | Male | 296.37 | 0.123 | 310.68 | 0.176 |
| | Female | 319.64 | | 290.31 | |

The respondents are composed of 287 (47.28%) students who graduated from private schools and 320 (52.72%) students who completed their senior high school in public institutions. Based on the results, students who graduated from public school got a higher mean score ($\bar{x}$ = 8.24, SD = 4.10) and are more confident on their answers (MC = 3.03) as compared to the students who completed their senior years in a private school ($\bar{x}$ = 7.84, SD = 3.84; MC = 3.00). However, these numbers are statistically the same.

The location of the school was also investigated. The results indicate that there are 535 (88.14%) respondents from the urban schools as compared to 72 (11.86%) who are from rural schools. When their mean scores in the assessment were calculated and compared, the results revealed that students who are from urban schools have statistically higher mean score ($\bar{x}$ = 8.21, SD = 4.11; p = 0.019) and are more confident on their answers (MC = 3.03; p = 0.009) as compared with mean score of students who graduated from rural schools ($\bar{x}$ = 6.93, SD = 2.66; MC = 2.88).

In addition, there are more male respondents (n = 408, 67.22%) than female respondents (n = 199, 32.78%). When their mean scores were compared, it was found out that female students have higher mean scores ($\bar{x}$ = 8,71, SD = 5.07) than males ($\bar{x}$ = 7.73, SD = 3.28) in the assessment (p = 0.004). However, this difference of scores is not significant. In terms of confidence, both groups have the same level of con-fidence on their answers, but males are slightly more confident on their answers than females. Never-theless, Table 3 shows that this slight difference in their confidence is not significant.

## Discussions

The objective of this study is to assess the K-12 graduates using FMCE. There are several factors investigated in this study such as strand, type of school, location of school, sex, and their confidence on their answers. The FMCE was given to first year engineering students of a state-run university in the Philippines and was administered at the beginning of the class. This was implemented in the school

year 2019-2020 and 2020-2021. This is to determine the performance of students before discussing the Physics lessons at the university level.

Based on the results presented in Table 2, students have below average performance in the FMCE. The STEM group has slightly higher mean scores than the non-STEM group, however, their mean scores are statistically the same. Our results suggest that the senior high school strands do not significantly affect the performance of the learners unlike in the previous reports (Almerino et al., 2020; Malaga & Oducado, 2021). It was expected that STEM graduates will perform better in the FMCE since they have two (2) general physics subjects in their SHS years. However, the results tell otherwise.

The type of the school was also explored. One study reported that private school graduates out-perform public school graduates because of their advantaged background (Jimenez et al., 1991). On the other hand, a recent study shows that public schools perform better than private schools based on the national achievement test (Magulod. 2017). In this study, however, our data revealed that there is no significant difference between the performance of K-12 graduates, whether they graduated from a public or private school. This signifies that the public-school graduates have relatively similar, if not higher, performance with the private school graduates, who have better facilities. This may imply that there is a minimal gap between public and private school graduates.

Moreover, our results suggest that students who studied from schools located in cities have significantly higher performance than those who graduated from the schools in rural areas. Citing the OECD 2013 report, they mentioned that students who attend schools in urban areas perform better than the ones who attend schools in rural areas. In the Philippines, the urban-rural education inequality was also observed. It was stated that educational provisions should be implemented in the rural areas to address the urban-rural education inequality (Zamora & Dorado, 2015). This may suggest that educational reforms must be executed to bridge the gap on this inequality, for example, by decentralization approach Figueroa, L. L., (Lim & Lee, 2016).

The field of engineering is dominated by males, it is believed that males are somehow more adept at math and science than females. However, our results indicate that female students are at part with male students. This means that sex gap is addressed, giving equal opportunities to both male and female students.

This study, however, is limited to two batches of first year engineering students enrolled in the academic year 2019-2020 and 2020-2021. This was also administered in one of the engineering schools in the Philippines, hence, findings cannot be used to generalize the overall performance of K-12 graduates. There are rooms to explore and factors to count in order to adequately conclude the performance of K-12 across several factors.

## Conclusion

This study showed that engineering students who are STEM and non-STEM graduates have the same performance as assessed using FMCE. The type of school, whether they graduated from a public or private school, does not matter. On the other hand, students who graduated from schools in cities per-formed better than those who graduated in rural schools. Further, in the field of engineering dominated by male students, the female students are at par with them. Since the study was conducted in one school only, findings cannot used to generalize the performance of engineering students in the Philippines.

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