

Challenges in STEM Learning: A Case of Filipino High School Students

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Abstract

STEM education faces monumental challenges which are aggravated by the Industrial Revolution (IR) 4.0 and the current COVID-19 global contagion. These challenges also affect how students learn in the STEM discipline in the senior high school. This qualitative study employed a case research design which sought to investigate nature of the challenges in STEM learning among senior high school students in the Philippines. Semi-structured interview guide was used in gathering the qualitative data from the 20 STEM learners in a government-run secondary school in Zambales, Philippines. Findings showed that the students encountered challenges in the STEM program. Ten themes emerged based on the students' responses. These challenges encountered by the students revolved around three categories – course-related challenges, individual challenges and socio-cultural challenges. The study recommends that schools offering STEM academic strands may reframe and rethink their processes, practices and policies to address the students' challenges in STEM learning. Policy recommendations are also discussed in the paper to equip the students towards the demands of Industrial Revolution 4.0 and in the post-pandemic world.

Keywords: Challenges in STEM learning, IR 4.0, Post-COVID Era, Post-pandemic World, STEM Education

INTRODUCTION

The demand for science, technology, engineering and mathematics (STEM) workforce in the contemporary society is very high. Globally, educational institutions encourage students to take up STEM to enhance their STEM skills and literacy which are needed in the modern industries. With the emerging fourth industrial revolution (FIRe) and the Education 4.0, there is a need to re-focus STEM education to respond to the global challenges such as educational disruption brought about by COVID-19 pandemic. Significant global events such as disruptive technologies, FIRe, new set of future work skills, and the present COVID-19 global pandemic brought the education realm into the context of VUCAD² (Morales, 2020). VUCAD² (volatile, uncertain, complex, ambiguous, diverse, and disruptive) is now the new normal in education which features the fast-paced changing educational milieu (Morales, 2019; Morales, 2020; Waller *et al.*, 2019) which will continue to challenge every facet of society in the post-pandemic setting (Rogayan & Dantic, 2021).

In the Philippines, STEM learning starts in the basic education. During the senior high school (Grade 11-12), students may choose to enroll under academic track which offers the STEM

strand. The first batch of STEM senior high school students in the Philippines enrolled in June 2016 which marked the full implementation of the K12 basic education curriculum. The Philippines was the last country in Asia to have a 10-year pre-university basic education. The enactment of the Republic Act 10533 or the Enhanced Basic Education Act paved the way in the offering of senior high school which includes the specialized STEM field.

Based on the enrollment data of the Department of Education (2017) for the school year 2017-2018 as reported in Brillantes *et al.* (2020), STEM is the third most popular academic strand next only to general academic strand (GAS) and accountancy and business administration (ABM). Furthermore, The Commission on Higher Education report as cited in Rafanan *et al.* (2020) reveals that the completion rate across STEM disciplines is only 21.10% based on the average 5-year data up until 2016-2017. They cite the completion rates as follows, science (25.52%), mathematics (21.20%), information technology (19.56%), engineering and technology (18.97%), and medical and allied fields (14.38%).

For the first time, the Philippines joined in Program for International Student Assessment (PISA) 2018 with the main objective of assessing the quality of instruction in the country to

support its quest towards the globalization of educational standards (DepEd, 2019). However, the recent 2018 PISA results which came out in December 2019 revealed the dismal performance of the country in terms of mathematics and scientific literacy. The Philippines ranked last among 79 joining countries in literacy in reading and second from the bottom in literacy in mathematics and science (OECD, 2019).

With the challenges of low STEM enrollment and low scientific literacy, the researchers sought to explore through this qualitative case research the nature of challenges of senior high school students in learning STEM in the Philippine context.

METHOD

Research Design

This qualitative inquiry employed a case research design. Qualitative case study methodology assists researchers to perform an in-depth examination of complicated phenomena within a definite context (Rashid *et al.*, 2019). The present study explored the challenges in STEM learning of a case of Filipino students.

Participants

Twenty Grade 12 STEM students sampled conveniently from one Philippine government school served as participants in the case study. Participants were chosen based on the following inclusion criteria: (a) presently

enrolled in STEM academic strand; and (b) varied performance in STEM courses. The participants were distributed equally with 10 participants each for female and male. The age range of the students was 16 to 19. The participants speak both Filipino and English languages.

The study was conducted in a government-owned secondary school in Zambales, Philippines for the school year 2018-2019. The school offers STEM academic strand. The locale was chosen for convenience factors since the school is located near a national hi-way. The study was conducted prior to the COVID-19 pandemic declared by the World Health Organization in March 11, 2020.

Data Collection Tool

The semi-structured interview guide was used to gather the needed data. The researchers asked the core question: What challenges do you encounter in learning STEM? Follow-up questions were made to have an in-depth understanding of the challenges cited by the participants.

Data Collection and Analysis

After securing approval from the school and informed consent from the participants, the researchers scheduled one-on-one interviews with the participants. Prior to the formal interview, the researchers explained the purpose of the research and had short informal talk with the participants to

establish rapport between the interviewer and the participant. The interview lasted for about 10 minutes each participant and was audio-recorded.

To facilitate the analysis of data, “the recorded interviews were individually transcribed to arrive at an extended text” (Rafanan *et al.*, 2020, p. 44). Transcription of the audio recordings were made immediately after the interview (Hatch, 2002). For better interpretation, all the responses of the participants were translated to English since some of them answered the interview questions in Filipino, their native language.

The researchers performed “a manual coding of the responses and assigned broad code which serve as a

basis for the generated themes” (Rafanan *et al.*, 2020, p. 44). The themes were culled from the participants’ responses with corresponding significant statements. The frequency of responses was also included in the data presentation.

To ensure validity and credibility of the emerging themes and its corresponding descriptions, the researchers employed informant feedback via interview among select participants (Lincoln & Guba, 1985).

RESULTS AND DISCUSSION

The study described the different struggles that the students have encountered in STEM academic strand. Table 6 shows the themes generated in this qualitative research.

Table 6 Challenges of the students in STEM learning

Theme	Significant Statement	Frequency
Bulk of course requirements	The consecutive assignment of requirements. It's okay to give requirements but give us enough time to do accomplish it. [P7, Female]	9
Difficulty in conducting research	Making the research is really challenging. [P17, Female]	6
Level of difficulty of STEM courses	My weakness in mathematics because we have lot of subjects in mathematics. [P9, Male]	6
Expectations of being in the STEM program	The high expectations of the teachers to us. [P11, Male]	3
Teacher's pedagogy	In physics, we have a hard time understanding the lesson because we do not understand the way it was taught. [P3, Female]	3
Time management	The time-management especially when the requirements are simultaneously given. [P3, Female]	2

Theme	Significant Statement	Frequency
Financial constraint	The printing of research papers are very costly. [P4, Female]	2
Irrelevant performance task	There are some activities that are neither interesting nor relevant to our strand. [P4, Female]	1
Irrelevant subjects to preferred college degree	Some subjects do not fit in the course that I will take in college. [P8, Male]	1
Use of English in science classes	When there are oral recitations, you need to use English as the medium of language. [P19, Female]	1

Theme 1: The bulk of course requirements

Nine participants indicated that bulk of course requirements are challenging for them. One participant (P2) shared her experiences by stating that, *'due to the bulk of course requirements, we cannot pass it on the deadline.'* Another student also mentioned, *'it is challenging when teachers are giving some requirements then followed by immediately another requirements'* (P7). This implies that almost half of the participants perceive the bulk of course requirements as a challenge in STEM academic strand. They find it hard to comply with all the course requirements at a time. This negates the findings of Cooper *et al.* (2006) that a reasonable amount of schoolwork or requirement is a good thing, meanwhile it leans towards positive outcome on a learner's educational success. This implies that

teachers may also ascertain that the course requirements measures the intended learning outcomes and that these requirements are contextualized and are beneficial to better understand STEM concepts.

Theme 2: Difficulty in conducting student research

Another challenge that Grade 12 students encountered is the difficulty in conducting research. One female participant stated, *'research is essential, but still it is hard to conduct'* (P7). This reflects how participants see research as a complex and rigorous process. This implies that teachers in science must give more technical assistance and guidance to STEM students to ensure that the students follow the right research process. The teachers should also inculcate to the students the value of conducting research in their level and the scientific attitude that they need to exhibit to ensure the success in the

research venture. Although, there are unexpected challenges and problems in conducting research that may lead to academic failures (Bocar, 2009), it is still important to remind the students that failure is a crucial part of the learning process.

Theme 3: Level of difficulty of STEM courses

STEM is comprised of several different courses that a student should take. Six senior high school (SHS) students stated that difficulty in specific STEM courses is a challenge for them. Participant 3 said that he faces difficulty in understanding math concepts and another participant (P17) cited that there are many math courses in the program. It suggests that difficulties in each subject area are one of the challenges students face in STEM program. Similarly, previous studies showed that students face problems in various STEM fields such as science (Ralph & Lewis, 2018), math (Nelson & Powell, 2018), engineering (Saterbak *et al.*, 2016), and technology (Jimoh & Hassan, 2020).

Theme 4: Expectations of being in the STEM program

Three of the participants revealed that one of the challenges they encountered is the high expectation coming from their teachers and family members. This indicates that expectations from family members could pressure on the students which they considered as a challenge being in the

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STEM course. Family members must support the students instead to ensure academic success and higher achievement.

Theme 5: Adjustment to Teacher's pedagogy

Teacher's teaching style has a vital role in the learning process of the students. It can lead to a successful learning process of the students, but sometimes it is also a challenge encountered by the students in their learning process. Three participants stated that the adjustment to teacher's pedagogy is a challenge for them. One of them (P19) said that she has difficulty in specific courses because she cannot understand her lessons well due to her teacher's teaching techniques. This implies that the teacher's pedagogy is also seen as a challenge in STEM disciplines. It is therefore important for teachers to up-skill and re-skill themselves on the emerging and innovative STEM teaching strategies.

Previous research suggested the use of innovative pedagogical strategies to improve scientific literacy (Barantes & Tamoria, 2021; El Islami *et al.*, 2015; Fahrnisia *et al.*, 2020; Macanas & Rogayan, 2019; Nisa & Wilujeng, 2020; Parmin, & Fibriana, 2019; Rogayan & Macanas, 2020; Saefullah *et al.*, 2017). Teachers have prior perspectives and experiences that could stimulate their STEM teaching, so they are considered

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an important person within students' talent development (Margot & Kettler, 2019). Thuy *et al.* (2020) averred that for the successful execution of STEM education, teachers' pedagogical competence is a key factor.

The most serious difficulty with implementing STEM education programs is that many professional teachers lack the knowledge about the different engineering skills that are used in the industry (Portz, 2015). Hence, teachers have a hard time relating the concepts to their students or deploying them suitably as part of an effective STEM strategy (Portz, 2015). Further, teachers' STEM knowledge is an "absolute requirement to create a future-oriented learning environment" (Parmin *et al.*, 2020, p. 18).

Theme 6: Time management

Another challenge encountered by the students is the management of their time. One of the participants expressed, "*I have difficulties in time management if the requirements are given simultaneously*" (P5). Time management has a crucial role in attaining improved academic performance. Time management helps students set goals and urgencies and be systematic in using time (Kaushar, 2013). Scholarly literature revealed that effective time management undergirds success in student learning

(Amida *et al.*, 2020; Hensley *et al.*, 2018; Stewart *et al.*, 2020).

Theme 7: Financial constraint

Due to the different projects and course requirements that they needed to submit, financial constraint is also considered as a challenge among the STEM students. This suggests that the financial factor can be a hindrance in STEM education. This is similar to Dang's (2015) claim that one of the challenges identified in attaining educational achievement and for the development of society and individuals is financial capacity.

Furthermore, many studies support that one of the challenges in student' education is financial constraint (Alipio, 2020; Azarcon *et al.*, 2014). Thus, it is important for the schools to also ensure that students are supported through offering financial assistance or scholarship programs. In this way, students might be attracted to get STEM as their preferred academic strand.

Theme 8: Irrelevant performance task

One SHS student stated that an irrelevant performance task is a challenge in STEM learning. According to the student, the tasks being given to them are not that meaningful in the STEM program and that she does not its connection to her future career. This connotes that teachers may ensure that the performance tasks being given to the

students are relevant in the field. STEM teachers must include performance tasks which are most essential and relevant to the students' context.

Diverse facets of school context can directly or indirectly influence instructional practices, and also teacher's approaches are positively related to instructional practices (Thibaut *et al.*, 2018). Thus, it is important for STEM teachers to design relevant instructional plans which feature performance tasks that can enhance students' conceptual understanding and can increase their appreciation of science. Providing learners with a responsive classroom and appropriate learning tasks are indispensable towards the development of their 21st century skill sets (Albay & Eisma, 2021).

Theme 9: Irrelevant subjects to preferred college degree

According to one of the participants, some of his subjects are not related to the course that he wanted to pursue in college. He perceived that other STEM curriculum subjects are not relevant to the course he intends to take in college. This may imply that schools may need to recalibrate the most essential competencies per subject in the STEM curriculum to respond to the industry's emerging needs. STEM education encompasses the student's utilization of the math and science concepts they obtained through engineering design and

technology in an applied setting (Margot & Kettler, 2019).

Further, the STEM curriculum has involved the use of math and science principles for students to apply it through the application of computer architecture and technology. Math and science are now introduced into the student's actual needs so that they can connect and solve a real question (Chamberlin & Pereira, 2017).

Theme 10: Use of English in STEM classes

Use of the English language in learning STEM is essential to further broaden one's conceptual understanding in the discipline. But for some participants, using the English language in their STEM classes is a challenge. The use of English in science communication is also a challenge for STEM learners since English is a second language in the Philippines. According to Ishamina and Deterding (2017), most of the students are not fluent in English; some have a hard time constructing grammar, are unfamiliar with precise vocabulary, and cannot understand the grammatical pattern. Hence, the complexity of the English language may further complicate the students' understanding of scientific concepts and principles.

A thematic map was developed based on the emerging themes identified in the study (Figure 1).

As shown in the figure, the challenges in STEM learning were classified into three categories, course-related, individual and socio-cultural. The course-related challenges pertain to the STEM students' challenges in the offered subjects in the program and the overall curriculum requirements. This include the bulk of course requirements, level of difficulty of STEM courses, irrelevant performance tasks, and irrelevant subjects to preferred college degree.

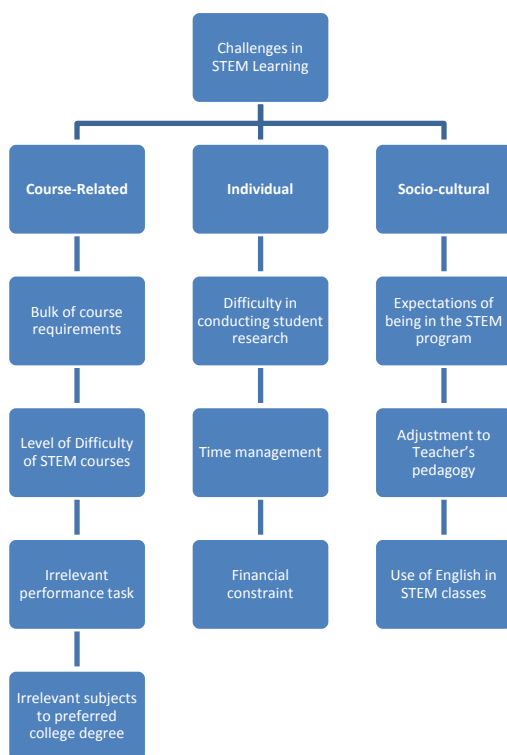


Figure 1. Thematic Map of the Generated Themes

The individual challenges refer to the personal challenges encountered by students in studying STEM. This include difficulty in conducting research, time management and financial constraint. Jurnal Penelitian dan Pembelajaran IPA Vol. 7, No. 2, 2021, p. 232-244

Lastly, the socio-cultural challenges deal with the challenges of the students that occur in their environment and in their cultural setting. This includes the expectations of being in the STEM program, teachers' pedagogy and the use of English in STEM classes.

Educational factors which are crucial for students' performance include instructional resources, school atmosphere, and compensatory instruction which are all connected to building a conducive physical, social, and psychological settings for learners and educators (Trinidad, 2020).

Limitations of the Study

Since the study is purely qualitative, several limitations must be pondered. The challenges of senior high school students in STEM learning in the locale may not indicate generalizability. This implies that the challenges encountered by the STEM students may not be the same in other contexts. Likewise, the small sample used in the study may have limited the responses of regarding the students' challenges.

CONCLUSION

The study highlighted the challenges of Filipino students in STEM learning. The challenges encountered by the students revolved around three categories – course-related challenges,

individual challenges and socio-cultural challenges. These challenges cited by the students may serve as a guide for STEM teachers, policy makers and other education stakeholders to rethink and reframe their processes, practices, and policies in teaching STEM among the learners.

To equip the STEM students towards the demands of Industrial Revolution 4.0 and in the post-pandemic world, it is recommended that STEM curriculum should be revisited and re-engineered to be more relevant and responsive to the demands of the new industrial revolution and the Society 5.0. Schools should continue to review and rethink the curriculum to be aligned in the current and emerging needs of the times specifically in the post-COVID-19 era. Inclusion of relevant, engaging and contextualized performance tasks in the program must also be done. Academic and financial support to financially-challenged but deserving STEM students may be explored to attract more learners to enroll in STEM academic strand.

Continuous retooling and professional development programs for STEM teachers must be sustained to align their pedagogy to the Generation Z students (born in 1995-2009) and the Generation Alpha (born in 2010-2024). Gen Z and Alpha Gen students are

naturally technology-savvy and digitally-proficient students.

Hence, further study may be done in other contexts and may involve larger sample. Another study may be done to explore the challenges in STEM learning during the COVID-19 educational disruption since the study was conducted during the pre-pandemic setting. A mixed-method research design may also be utilized to further validate the surfaced challenges in this research. The thematic map generated in the study may be further validated using robust sources and approaches.

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