AN INQUIRY INTO THE K TO 12 SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS STUDENTS' PERSISTENCE

MARISOL D. ANDRADA[1], ARLYNE C. MARASIGAN, PhD[2]
https://orcid.org/0000-0002-8053-316X[1], https://orcid.org/0000-0003-2362-7634[2]
andrada.md@pnu.edu.ph[1], marasigan.ac@pnu.edu.ph[2]
DepEd, Iriga City[1], Philippine Normal University, Manila, Philippines[1,2]

ABSTRACT

Due to the unprecedented change in science and technological advancement, strengthening of STEM Education in the Philippines becomes an important goal under the K to 12 Curriculum aimed to produce 21st century and globally competitive learners. The educational reform was implemented even in rural areas to lessen inequalities and poverty in consonance with Education for All (EFA) and Sustainable Development Goals (SGDs). Senior high school (SHS) students can take STEM strand towards STEM-related careers without going into Science high schools or universities. However, very few students are opting for STEM because of grade requirements and negative perceptions towards STEM. Those who enrolled failed to finish and graduate as STEM students. Hence, this study aimed to explore the factors that contributed to the persistence in STEM of selected SHS students. The study utilized a purposive selection of the seven participants (n=7) who are among the first successful STEM graduates under the K to 12 Curriculum in 2018. The participants underwent a one-on-one in-depth interview. Transcription, coding, and thematic analysis were employed to arrive at the insightful narration of their lived experiences as STEM students. Based on the results gathered, the factors that contributed to the persistence of the SHS students are self-efficacy and social support. The result of the study provides sound evidence that cognitive, affective, and psychosocial support from parents, family, peers, teachers, and school are essential for students' success. Students should have the freedom to choose the track/strand they wanted to pursue. School authorities must provide relevant activities that could strengthen STEM initiatives and implementation among SHS students.

Keywords: STEM Education, Persistence, phenomenological study, K to 12 Curriculum, Philippines

INTRODUCTION

Science and technology are vital to a nation's economic productivity, prosperity, and social development. However, the unprecedented advancement in technology brought about by the 4th Industrial Revolution or IR4.0 brings a threat to the global economy and race for technological superiority (Delp, 2016). Additionally, researches show a mismatch between science skills and the STEM workforce; the quality of STEM students continues to deteriorate, and there is a significant decline in the number of students opting for science and mathematics. This decrease in the quality and quantity of students in STEM leads to a low retention rate because students believed that success in STEM is a pre-given talent that leads to a separation between high achievers and low achievers. Moreover, issues of equality and equity in terms of gender, race, status, ethnicity, school facilities and equipment, support of internal and external stakeholders, school location and performance, instruction, and funds persist. But, the implementation of Education for All (EFA) and Sustainable

Development Goals (SGDs) prompted countries for educational reforms that are inclusive and equitable for all (Incheon Declaration for Education 2030). In the Philippines, the legalization of the Republic Act 10533 or Enhanced Basic Education Act of 2013 set the basis for the holistic development of 21st-century learners equipped for higher education, entrepreneurship, employment, or middle-level skills development after graduation. These objectives are targeted through a 12-year formal education that is free, accessible, complete, suitable, relevant, and beneficial to both the individual and the country's economy. An additional two years called Senior High School (SHS) allow students to choose among various tracks/strands based on his/her skills, talent, and interests. Treated in silos or integrated, Science, Technology, Engineering, and Mathematics (STEM) permeate every inch of the students' lives, hence, the call for a transformative education. An education that will enable 21st-century students to improve their capabilities more than the skills suited in the past century. The current Science Curriculum Guide is knowledge- and context-based towards critical thinking, creativity, innovation, problem-solving, scientific processes and skills, understanding and applying scientific knowledge, informed decision-making, social responsibility, and effective communication for sustained economic growth and stability. Furthermore, the science curriculum seeks to ignite the students' desire and love for a STEM career. Offered nationwide, SHS students can opt to take STEM strands towards STEM-related careers without going into Science high schools or universities. However, very few students are opting for STEM because of grade requirements and negative perceptions towards STEM. From 220,590 Grade 11 students enrolled in public, private, and SUCs in 2016 – 2017, only 192,624 continued to Grade 12 in 2017-2018. Only 183,958 students persisted in graduating in April 2018. Williams-Watson (2017) enumerated factors that contributed to the African-American and Hispanic students' persistence in STEM education. These are childhood experiences and interests, self-motivation, positive educational experiences in secondary school, family encouragement and values, positive experiences with professors, lack of educational preparation, lack of minorities, clubs, and organizations, the need for financial assistance and friends within the major. Furthermore, attitudes, beliefs, perceptions of pedagogies, desire for more mathematics, confidence, and enjoyment influence students' persistence in STEM (Wu, 2018). According to Wu (2018), student retention, or equivalently, student persistence refers to students persisting in major in the same university, or continuing in a university with a different major, or persisting in education in a different university. Additionally, Ellis, Kelton, and Rasmussen (2014) defined a persistent student as one who declared and eventually graduated with a STEM major. In education, it is a high motivation that will aid students in achieving their academic and personal goals powered with high motivation, especially in STEM, considered as difficult. The paper assumed that the factors identified by Williams-Watson (2017) and Wu (2018) contributed to the students' persistence in the SHS-STEM Track/Strand. The students who persisted in this paper enrolled in STEM in Grade 11 in 2016-2017, continued to Grade 12 and graduated in 2017-2018 in the same institution. The number of students who remained in the school or persisted pertains to the retention rates. Schools typically measure retention rates every year. The study aims to contribute pieces of information that can help identify areas for improvement in increasing students' persistence in STEM in the new curriculum, which will gear towards achieving the targeted reforms.

OBJECTIVE OF THE STUDY

The study aimed to explore how self-efficacy and social support contributed to the persistence in STEM of the first K to 12 graduates.

METHODOLOGY

The study used the phenomenological approach, which focused on exploring the lived experiences of the first SHS graduates in the STEM track/strand. Phenomenological research is a qualitative research method used by researchers to find essence (meaning) on the experiences of people who experienced a concept or phenomenon (Creswell, 2007). The study used a purposive selection using the fishbowl technique in determining the seven participants for the study. The participants were graduates in an SHS offering STEM strand only. There were 54 enrollees in Grade 11 in SY 2016-2017, but only 48 students graduated in April 2018. The selected participants currently in college, taking up STEM-related courses and education courses major in science, were all willing to take part in the study. Before the interview, the researchers prepared an interview protocol consisting of open-ended questions. It underwent peer evaluation and pilot testing with two K to 12 STEM graduates. They were not included in the final meeting to circumvent data contamination. The pilot test helped the researcher make the necessary adjustments to make it more suitable in obtaining the needed response to the research objective. Participants signed informed consent in both the pilot and final study. An orientation on the necessary information about the study, confidentiality, and anonymity procedures of the study took place. Participants had the option to halt the interview at any time. One-on-one in-depth interviews at an average of 40 minutes happened in a mutually agreed location. Likewise, a phone interview with three of the participants enrolled in schools outside the city or region. Both conversations, face-to-face, and phone interviews were recorded using digital recorder upon participants' approval. The documented interviews underwent verbatim transcription. Cool and warm analyses were used in the treatment of field data. The cool investigation involved highlighting statements, sentences, and phrases relevant to the experienced phenomenon. Themes were formed from the highlighted terms using manual clustering. The study utilized Moustakas's modification of the Stevick-Colaizzi-Keen phenomenological method to describe the "what" and "how" the participants experienced the phenomenon. From there, in-depth knowledge to give essence to the lived experiences that contributed to the persistence in STEM of the first K to 12 graduates conceptualized a model from the emergent themes. Member checking through personal messages ensured the integrity of the results. The data gathered were filed in a systematized folder digitally.

RESULTS AND DISCUSSION

1. An Inquiry into the K To 12 Science, Technology, Engineering and Mathematics Students' Persistence

To probe answers to the central question: How do self-efficacy and social support contribute to the students' persistence in the SHS-STEM program? Open-ended questions with follow-up questions guided the one-on-one interview. Cold and warm analyses of data led to a model labeled Success model consisting of students' persistence in the program as a result of Self-efficacy coupled with Social support, as shown in figure 1.

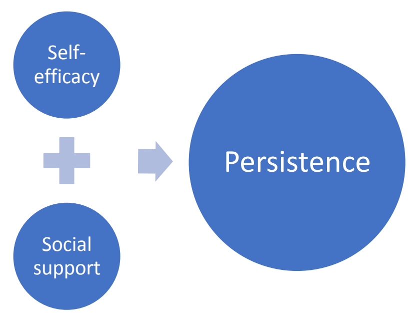

Figure 1 Success model

Seven participants, all females, retorted to be part of the study. Table 1 contains the necessary information about the participants.

Table 1 Participant's Information

Participant	Year in College	STEM course
P1	First	BS Electronics Engineering
P2	First	BS Civil Engineering
P3	First	BS Psychology
P4	First	BS Civil Engineering
P5	First	BS Physical therapy
P6	First	BSEd major in Science
P7	First	BS Civil Engineering

1.1 Self-Efficacy

Not all the participants said it was their first choice enrolling in STEM. However, the participants joined and persisted in the STEM program because of belief in themselves and in God, proper time and resources management, positive outlook in life, motivation, and determination. Generally, the participants' reasons for their choice were more on personal preference and intrinsic interest. The participants' intended course in college and outlook to test themselves with STEM subjects influenced their decisions.

"Yes, it was my first choice. I dream of becoming an engineer. I believed that this strand would help me a lot." (P1).

"It was my first choice. I wanted to challenge myself to better understand the hard subject, Mathematics" (P4).

"This is my first choice. In STEM, I can show my ability to compete with my fellow students; and it influences me to develop my self-confidence" (P5).

"It wasn't my first choice. My mother and friends influenced me to take the track. I wanted tourism in college. People say STEM is the highest of all the strands. It is considered difficult, so it's better challenging ourselves and get around our weaknesses. Mathematics is my weakness. I wanted to get better on it. Leaving our comfort zone to explore and enhance our knowledge of other things is a better thing to do" (P3).

The participants believed that relying on others' help will not help them succeed. Instead, they should have focus, motivation, and perseverance to strive harder in overcoming all the challenges. The participants' self-efficacy dictate a persons' feeling, thinking, motivation, and behavior, which results in diverse effects in their cognitive, motivation, affective, and selection developments (Bandura, 1994). The participants developed a strong belief in their abilities, and strong commitment partnered with proper time and resources management to survive the tasks and challenges.

"It was difficult for me to do our requirements. There were no references and no internet connectivity. We were required to use Quipper and Edmodo. And problems with math lessons but through perseverance, hard work, guidance, and use of my allowance to load for the internet to do research, everything that you do if you work hard, you will get what you want. I trusted myself in the sense that I know I can do better as much as others can do" (P2).

"I remember there were times that our reviewers are mixed up for tomorrow's exam again, hahaha…I started to cry because of stress…ahhh…but by studying hard to achieve something; you will sacrifice and fight to claim it. I put in my mind that I'm ready to face any challenges as a STEM student. I believed that I could. It was fulfilling. It feels good to attain success despite the hardships" (P4).

In any situation, activities that support and boost persons' abilities develop optimism or a positive attitude that makes people tough in facing obstacles to achieve one's goals. Goals either classified with achievement goals theory and self-determination theory motivated the participants. Achievement goals refer to the aim or purpose a person tries to achieve dictates a person's behavior in an educational setting. The goals can be about challenging oneself to gain new knowledge or skills to increase one's faculty at the same time showing one's ability by outdoing others. On the other hand, self-determination theory refers to peoples' intrinsic needs of competence, autonomy, and relatedness. The participants achieved complacency in facing challenges and manage their lives while building capability and mastery (David, 2014). Five of the participants used their goal and their many reasons to surpass whatever problems/struggles they were in as STEM students. The participants' high intrinsic motivation governed them to persist in the program.

> *"I always had positive thought. I mean K to 12 is new, and we never knew what will happen, what are the things we will encounter, so in everything I do, working hard will get me to what I want. Don't let your emotion control you; don't let fear stun you, fight it, be optimistic, and you will be successful" (P6).*

> *"I've set a goal for me to pursue more and strive harder to overcome all the challenges. It was tough, but the motivation to graduate helped me to face every hardship" (P4).*

> *"I managed my time to meet all the requirements, especially when there were a lot of projects and activities to do. And my resources when I am in financial needs for the projects (individual or group), and the exam (practical exam; Science Quiz; Paper and pen tests), so don't give up" (P7).*

Additionally, reliance and faith in God helped the participants persevere in the program. Responses include,

> *"I asked God's help and surrendered to Him. I saw His unmeasurable blessings to me. I thank God that I passed all my subjects in Grade 11 then Grade 12 through prayer. I feel great. Nothing is impossible with God. I did my best for all His Glory" (P4).*

1.2 Social Support

Parents, family, friends and teachers, selflessness, materialism, and pragmatism are other reasons why the participants were in the STEM program. The socioeconomic status of the family and parents' independence in choosing a school for their children based on location, school design, and quality of education (OECD, 2012) influenced the participants to take STEM based on practicality, accessibility, and convenience.

> *"My parents and my dreams influenced my choice. Their dream for me was to be an engineer someday" (P1).*

> *"My family, my Grade 10 adviser and other teachers, my friends, and myself, I influenced my mind to decide to take STEM strand" (P4).*

> *" The school is near. I walk from the house to school. I will have fewer expenses in terms of daily fare, allowances, and others. That's why, instead of going to the city proper, I took STEM since it is the only track/strand available in school" (P2).*

Additionally, the family influenced the participants' persistence by giving profound importance to education. To make their families' lives better, they guided the participants to remain and finish the STEM program.

"I want to help my parents and give them a good life. I can do that if I finish my studies. They told me I could do it" (P1).

"I have to study well for my dreams and my family. I will become a licensed physical therapist to obtain a bright future for them" (P5).

The participants emphasized the stressful demand for requirements in almost all subjects. They were like robots at times following orders or going from one class to another with unfinished tasks. However, the interaction and relationship established with peers, teachers, and personnel (David, 2014) inspired and challenged them to persevere and take STEM-related courses after graduation. When students were satisfied with the relationship with students and other stakeholders within the institution, retention, or persistence becomes high. The support from and rapport with teachers pushed them to the limit of achieving their goal.

"It is more fun in STEM because of the thoughts and life lessons from the teachers. I owe them for teaching me how to be a good STEM student. They helped me to learn more" (P2).

"I was challenged by our teachers. I liked their "pakikitungo/pakikisama." I'm thankful I met and known them. I learned a lot. They honed our minds by challenging us" (P4).

The camaraderie established with peers and friends helped them persist in the STEM program, especially at times when they wanted to surrender. Friends were there through thick and thin.

"My friends helped me cope up with the pressure. It is when we help each other and strived harder to reach our dreams. Then after a stressful day, we still managed to have some fun to de-stress. When graduation came, I felt relieved, at the same time, sad because we'll be separating our ways" (P3).

When teachers assessed and reflected on their pedagogy, STEM-related activities and experiences were created and facilitated. STEM lessons that were enjoyable, engaging, and relevant through the student-centered learning paradigm encouraged the participants. It allowed and supported everyone in the classroom to learn, regardless of intellectual ability, socioeconomic status, language, race, ethnic background, gender, or religion (Cantu, 2015). Furthermore, Tang et al. (2017) posited that authentic inquiry learning could promote equity. It develops better student-student and student-teacher relationships because of open communication.

As it is, learning with peers inside or outside the classroom occurred. Students became responsible and took ownership of their education by building new knowledge from prior experiences through brainstorming. There was a success in the understanding of the topics at hand. Moreover, the integration of technology experiences (Hayden, 2011) increased the students' knowledge, attitudes, and interest towards STEM. Positive experiences (Kling, 2016), like the Work Immersion, also brought a positive impact on the students towards continuing to STEM-related courses.

"I enjoyed the various strategies used by our teachers like short film making, dream invention (webpage), separation techniques, reporting, graphic organizers, cooperative learning, poster making, laboratory activity/Inquiry learning, role-playing, debate, group project, demonstration, and video clips." (P2)

"The 3D models we did for practical activities made me feel like I am an engineer. Another was when we assembled a circuit to check the voltage that lighted the lamp using a voltmeter. The

activities inspired me to love STEM more. I was in the Engineering Office during my immersion. The engineers were using AutoCAD in plotting. I learned it. Now I have AutoCAD subject; I do not find it difficult" (P1).

CONCLUSION

The study used the phenomenological approach to explore and describe how self-efficacy and social support contributed to the persistence in STEM of the first SHS graduates.

1. Self-efficacy refers to the participants' belief in themselves and God**,** proper time and resources management, positivity, motivation, and determination while Social support pertains to the assistance (financial, physical, emotional, and mental) from parents, family, friends, and teachers. These refer to the cognitive, affective, and psychosocial factors that play an essential role in and out of the classroom.
2. The students' attributes, including attitudes, beliefs, confidence, enjoyment, and desire for more, perception on strategies, willingness to challenge themselves to acquire new knowledge, and to be in control of their lives while networking with people around them helped them succeed in the program.
3. The result showed a significant relationship existed between parent aspirations, students' beliefs, activities outside the classroom, and STEM persistence.

RECOMMENDATION

While positive factors were found essential to the students' persistence in STEM, the following points are for future consideration:

1. The students may have the autonomy to choose strands for themselves while supporting them to persevere by instilling the value of education.
2. Institutions and administrators may deepen their understanding of STEM education and possess positive perceptions to implement inclusive STEM initiatives and changes in the curriculum.
3. Intensify continuing teacher professional development focused on pedagogical content knowledge and interventions to affect positive change in teachers' perceptions towards STEM initiatives.
4. Teachers may have precise information about the effective implementation of STEM education. Such steps will ensure the development of students' 21st-century skills, autonomy, and the scientific mind in daily school activities.

ACKNOWLEDGMENTS

The author extends sincere gratitude to all the people who have contributed and served as inspiration in the study.

REFERENCES

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), Encyclopedia of human behavior (Vol. 4, pp. 71-81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], Encyclopedia of mental health. San Diego: Academic Press, 1998) Retrieved from: https://www.uky.edu/~eushe2/Bandura/BanEncy.html

Cantu, D. V. (2015) *Applying Reflection and Self-Assessment Practices to Integrative STEM Lessons: A Design-Based Research Study to Develop an Instrument for Elementary Practitioners*. Doctor of Philosophy (PhD), Dissertation, STEM and Professional Studies, Old Dominion University, DOI: 10.25777/jaq8-0263 https://digitalcommons.odu.edu/stemps_etds/60

Creswell, J. W. (2007). *Qualitative Inquiry and Research Design: Choosing among Five*

Approaches. Second Edition. Thousand Oaks, CA: Sage Publication

Delp, M. J. (2016). *Investigating the Criteria and Processes used in the Selection, Implementation, and Evaluation of STEM within K–12 Education. Retrieved from* https://pdfs.semanticscholar.org/3488/58c64559f8e69a852720fc73dcfdc52a95ef.pdf

David, L. (July 16, 2014). "*Self-Determination Theory* (Deci and Ryan)," in *Learning Theories.* Retrieved on November 18 from https://www.learning-theories.com/self-determination-theory-deci-and-ryan.html.

Ellingson, C.L. (2018). *Teachers as Curriculum Designers: Understanding STEM Pedagogical Design Capacity*. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/199085.

Ellis, J., Kelton, M., & Rasmussen, C. (2014). Student Perceptions of Pedagogy and Associated Persistence in Calculus. ZDM – *The International Journal on Mathematics Education*, 46(4), 661-673.

Hayden, K., Ouyang, Y, Scinski, L., Olszewski, B., & Bielefeldt, T. (2011). *Increasing student interest and attitudes in STEM: Professional development and activities to engage and inspire learners.* Contemporary Issues in Technology and Teacher Education, 11(1), 47-69. Retrieved from: http://www.citejournal.org

Incheon Declaration and SDG4 – Education 2030 Framework for Action (2016). ED-2016/WS/28. p.7/86. Retrieved on June 30, 2019, from https://unesdoc.unesco.org/ark:/48223/pf0000245656

Kling, R. R. (2016). A case study to determine if HOI-STEM courses influenced students' decisions toward continuing their studies in the HOI-STEM areas (Order No. 10243829). Available from ProQuest Dissertations & Theses Global. (1858815067). Retrieved from https://search.proquest.com/docview/1858815067?accountid=17301

Miller, J. A. (2015). *Predictors of student persistence in the STEM pipeline: Activities outside the classroom, parent aspirations, and student self-beliefs using NELS:88 data* (Order No. 3684530). Available from ProQuest Central; ProQuest Dissertations & Theses Global. (1660753267). Retrieved from https://search.proquest.com/docview/1660753267?accountid=173015

Organization for Economic Co-operation and Development (2012). Equity and Quality in Education Supporting Disadvantaged Students and Schools. Paris. Retrieved on June 30, 2019, from https://asiasociety.org/education/equity-and-quality-education

Enhanced Basic Education Act of 2013 (May 15, 2013). Republic Act No. 10533: An Act Enhancing the Philippine Basic Education System by Strengthening its Curriculum and Increasing the Number of Years for Basic Education, Appropriating Funds Therefore and for Other Purposes. Retrieved from: https://www.officialgazette.gov.ph/2013/05/15/republic-act-no10533/

Sandall, B. K. (2016). *Investigating Educators' Perceptions of STEM Integration: A Semi-Structured Interview Approach. https://digitalcommons.unomaha.edu/srcaf/2016/Schedule/21*

Tang, G., El Turkey, H., Cilli-Turner, E., Savic, M., Karakok, G., & Plaxco, D. (2017). Inquiry as an Entry Point to Equity in the Classroom. *International Journal of Mathematical Education in Science and Technology*, 48:sup1, S4-S15, DOI:10.1080/0020739X.2017.1352045

Tinto, V. (1975). Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational Research, 45*(1), 89-125.

Walker, I. & Zhu, Y. (2013). The Benefit of STEM Skills to Individuals, Society, and the

Economy: Report to Royal Society' s Vision for Science and Mathematics. Report to Royal Society's Vision for Science and Mathematics, 1–38.

Williams-Watson, S. (2017). *Persistence among minority STEM majors: A phenomenological study.* https://ui.adsabs.harvard.edu/abs/2017PhDT........50W/abstract

Wu, X. (2018). *Persistence and Characteristics of Calculus I Students in STEM Disciplines* (2018). Graduate Theses, Dissertations, and Problem Reports. 7279. https://researchrepository.wvu.edu/etd/7279

AUTHORS' PROFILE

MARISOL D. ANDRADA graduated Bachelor of Secondary Education major in Physics, under Department of Science and Technology-Science Education Institute (DOST-SEI) undergraduate scholarship, at Bicol University College of Education (BUCE), Daraga, Albay in 1996, and Master of Arts in Physics Education (MAPE) at Bicol University Graduate School (BUGS), Legazpi City in 2000. She is currently completing her degree in Doctor of Philosophy in Science Education, under the Department of Science and Technology Science Education Institute - Capacity Building Program for Science and Mathematics Education DOST-SEI-CBPSME), at Philippine Normal University, Taft Ave. Manila, Philippines. She had been a science teacher at San Antonio National High School, Iriga City since 1996, and served as Science Area Coordinator since 2004. In 2014, she was an International Leaders in Education Program (ILEP) fellow at Arizona State University, US. She is currently a Master Teacher I at Sto. Nino National High School, Iriga City since 2016 handling SHS-STEM. She had been a trainer in school, division, and regional training.

ARLYNE C. MARASIGAN, Ph.D. is an assistant professor at the Philippine Normal University-Manila. She teaches Science Education and Educational Leadership programs offered by the College of Graduate Studies for Teacher Education and Research. Dr. Marasigan holds a PhD in Educational Leadership and Policy major in Comparative Education from Beijing Normal University, under Chinese Government Scholarship (CSC). She obtained her Master of Arts in Education major in Chemistry at the University of the Philippines-Diliman, and her Bachelor of Secondary Education major in Chemistry, under Commission on Higher Education (CHED) Scholarship, graduated *Cum Laude* from the Philippine Normal University. Last 2018, she completed her academic requirements in Doctor of Philosophy in Philippine Studies at the University of the Philippines-Diliman, Tri-College. Before she joined the Philippine Normal University as a faculty member, she had worked at Diliman Preparatory School (DPS) and served as Subject Area Coordinator at High School Department for five (5) years. Prior to the implementation of the K to 12 curriculum and in collaboration with UP-NISMED research specialists, she spearheaded the enhancement of Stream subjects offered as an elective course for high school students. Her team developed subjects such as astronomy, environmental science and science research 1 and 2 which are now part of the regular DPS high school curriculum. As a science educator, Dr. Marasigan has several international collaborations from different disciplines including Chemistry, Science Education, Teacher Education, Curriculum Studies, Philippine Studies, Education for Sustainable Development (ESD), and Comparative Education to name a few. She has been an active country's representative in the four-country Asian collaboration (i.e., Japan, South Korea, Malaysia and the Philippines) on ESD, Green Chemistry since 2012.

COPYRIGHTS