STEM Education from Asia

Trends and Perspectives

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Chapter 7

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7 Advancing integrated STEM education in the Philippines through STEM curriculum implementation

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Introduction

Science, Technology, Engineering, and Mathematics, or STEM, has increasingly been the focus of the school's curriculum over the past ten years specifically in the United States of America and United Kingdom (Banks & Barlex, as cited in Hallström & Schönborn, 2019). This STEM-focused education was extended to and continues to grow in Asian countries where a deliberate integration of engineering design or design thinking in STEM subjects has been observed or where the problems that have been investigated by students have real-world orientations and are multidisciplinary in nature (Lee et al., 2019). In the case of the Philippines, STEM is introduced in the formal school curriculum as one of the strands in the academic track in senior high school (SHS).

In Southeast Asia, the Philippines is next to Indonesia in terms of manpower pool in the region, with 27,216,398 learners during the school year 2019–2020. Of this enrollment, 3,194,035 are in SHS and only 491,349 (15.38%) are on the STEM strand (Department of Education [DepEd], 2019). Do these numbers indicate students' lack of interest in STEM? Is there an integrated STEM curriculum in the Philippines?

STEM education in the K to 12 senior high school programme

The landscape of basic education in the Philippines changed when the K to 12 Basic Education Curriculum was implemented under the Enhanced Basic Education Act of 2013, a law signed by the former Philippine President Benigno Aquino III (officialgazette.gov.ph, 2013). This curriculum requires Filipinos of this generation to complete 13 years of basic education from Kinder to Grade 12. Prior to the said law, the basic education was only from Kinder to Grade 10.

The SHS Programme (Grades 11 and 12), the new addition to the curriculum, is designed to cater for the needs and interests of students and provide opportunities for possible employment. It allows students to select a track that they intend to pursue. There are four basic tracks: Academic, Technical-Vocational-Livelihood

(TVL), Sports, and Arts and Design. The Academic Track includes the STEM strand, among three others. The STEM strand is intended for students who would be pursuing STEM-related college courses and careers.

The STEM curriculum of the Department of Education includes three subject classifications: *Core subjects*, *contextualised subjects*, and *specialisation subjects*. STEM subjects such as Earth Science, General Mathematics, and Statistics and Probability fall under the *core subjects* along with other subjects such as Physical Education and Health, Languages, Arts, Philosophy, etc. *Contextualised subjects* are subjects where students can apply what they have learned and what they can utilise for their future academic track and careers. *Contextualised subjects* include Research, Entrepreneurship, Languages for Professional Purpose, and Empowering Technologies. Lastly, the *specialised subjects* include three major fields in science: Biology, Chemistry, and Physics. Each subject is tackled twice for an academic year, with the first subject serving as a pre-requisite to the other. For example, General Chemistry 1 is taken during the first semester and General Chemistry 2 during the second semester. For Mathematics, the specialized subjects are Pre-Calculus for the first semester and Calculus for the second semester (DepEd, 2013).

STEM education programme challenges

According to a number of national and international assessments of student's learning, it has often shown that the state of science and mathematics performance in the Philippines needs improvement. Despite a good number of recognitions brought by Filipinos in the field of science, technology, and innovation, these recognitions are still often overshadowed by the poor standings of Filipinos in terms of science and mathematics education in comparison to other countries (Imam et al., 2014). The rise of multiple reports published about the educational crisis in the past years triggered the dire need for major changes, opportunities, improvements, and expansions in STEM education. Although the call to action is heightened, the transition to and the change in curricula have not been easy (Sahin, 2015).

Among the numerous crises faced by the improvement of STEM education in the country is the lack of educators with exceptional mastery in the field related to STEM (Feliciano et al., 2013). Poor performance in the national Basic Education Exit Assessment (BEEA), which is taken by all exiting SHS Grade 12 students, has been reported. In the 2019 BEEA, the mean percentage score in Science was 36.2% and 27.9% in Mathematics (DepEd, 2019). In terms of the number of students at the tertiary level, only 28.7% of the 3.2 million university and college students are in STEM-related courses such as agriculture, forestry, fisheries, sciences and mathematics, engineering, and information technology (CHED Statistics, 2019). The STEM pipeline further narrows as reflected by the low number of research and development professionals. Specifically, the ratio of research and development personnel per million population is only 245

compared to Malaysia that has 3,912 and Vietnam with 1,825 R&D personnel per million population (UNESCO UIS, 2019).

Globally, STEM education aims to develop STEM engagement literacy under the 21st-century competencies and a workforce that is STEM-capable (Honey et al., 2014). These goals are developed for students to become critical and creative thinkers who can develop innovations, solutions, and sound decisions. The purpose of STEM education is to produce a workforce that is capable of contributing significantly to the industry of their choosing. Similarly, the Philippines shares the same STEM goals, with slight modification, which are anchored to DepEd's four core values – *maka-Diyos (for God)*, *maka-tao (for the people)*, *makakalikasan (for nature)*, and *makabansa (for the nation)* (Vera Cruz et al., 2018). Despite these common goals, STEM education does not show significant integration across its subjects.

Integration of STEM subjects is not evident in both basic education and higher education. In particular, at the basic education level, all sciences and mathematics are tackled as different subjects without underlying themes. Looking through the STEM curriculum for SHS, it is clear that STEM subjects are all taught separately. As mentioned, the three major science fields are taught as separate subjects across the semesters from Grade 11 to Grade 12. Additionally, most students treat each STEM discipline as separate subjects and their ability to make connections across these disciplines is difficult to measure (Honey et al., 2014). This also affects their collaborative capabilities in problem solving in which STEM can be applied. Furthermore, every STEM subject is assessed separately through its own standardised achievement test which fails to measure the connections among STEM subjects. For instance, inter-school research competitions are classified into different categories based on a specific science field. Competing students for science research categorise their studies under either life or applied science which is assessed separately. In junior high school, though all three major branches of science are taught in every grade level, there is still a clear demarcation; that is, where they are taught in separate grading periods with unclear underlying themes and integration. The integration of STEM subjects and across other learning disciplines should be targeted. When such is achieved, learners' critical and creative thinking skills will be developed and consequently be applied in innovation, problem solving, and decision making.

Rationale for a STEAM innovation programme

Crucial to nation-building and economic prosperity is a citizenry who are not only consumers or end-users but are also producers, entrepreneurs, creators, and innovators. The development of such citizenry is deeply rooted in human capital development through high-quality education and training that foster a culture of innovation and collaboration.

Filipinos may already have the seeds and fertile ground for which innovative and collaborative mindsets can be cultivated. The 2015 Global Entrepreneurship Monitor reported that the perceived entrepreneurial traits of Filipinos are above

world averages and are also higher compared to their Asian neighbours (Sansano, 2018). For instance, Filipinos rated higher in terms of perceived opportunities, perceived capacities, entrepreneurial spirit, and innovation compared to Malaysia, Vietnam, and Thailand. Moreover, Filipinos already have a substantial online presence having 67 million internet users who spend an average of nine hours a day on the internet (We Are Social, 2018).

Despite the high entrepreneurial and innovative spirit of Filipinos, the Philippines' global innovation performance only ranks 73rd in the world, compared to its Asian counterparts such as Malaysia (ranked 35th), Thailand (44th), and Vietnam (45th) (Sansano, 2018). Furthermore, the strong digital connectedness of Filipinos has yet to be channelled into a thriving e-commerce. The Philippines only gets 39% share of people buying online in contrast to Malaysia and Thailand, which have 59% and 62% share, respectively (Sansano, 2018). The way to turn this around is through human capital development – education and training that consciously create a culture of innovation and collaboration. This is strongly articulated in the agenda of various government agencies such as Ambisyon 2040: The Philippine Development Plan (NEDA), Science for the People (DOST), and the Inclusive Innovation Industrial Strategy (i3 Strategy-DTI).

The Department of Education already has a considerable platform for human capital development on innovation and collaboration because of its STEM curriculum in SHS. However, its implementation needs to be supported by sustained capacity-building of both teachers and learners on authentic STEM practices for developing innovative products or optimised processes/services. It also needs a mechanism for sharing students' innovations with their communities. Hence, the STEAM Innovation Programme for SHS has been conceptualised and implemented.

STEAM innovation programme

The STEAM Innovation Programme is a project with Unilab Foundation that aims to create and sustain a culture of innovation and collaboration through partnership with local communities, teacher capacity-building, sustained professional development, and community expos involving public SHS that offer STEM.

Consultation with stakeholders

The first phase of the programme engaged the local community stakeholders. Through a roundtable discussion involving school leaders, local government officials, and local business owners, potential areas for innovation such as local industries that can benefit from research and community problems that can be addressed through scientific means were identified. A follow-up focus group discussion (FGD) among fisherfolks, farmers, and local government officials was also carried out. Responses from the roundtable discussion and FGD were

analysed, categorised into themes, and developed into a STEAM research and innovation agenda.

Teacher capacity-building

The second phase of the programme included a workshop for building the capacity of teachers. Specifically, a workshop on Design Thinking Process immersed teachers in several classroom strategies for empathising, problem finding, generating and distilling ideas, prototyping, testing, and communicating to guide STEM students in developing innovations that are responsive to community needs or aligned with local business needs. In addition, the STEAM research and innovation agenda that had been generated from the previous consultation with stakeholders was introduced to the teachers. There was a discussion on how the agenda could be used for the problem-finding stage of the design thinking process.

Innovation-focused curriculum

An SHS curriculum that embeds design thinking was developed to ensure that the innovation programme reached the classrooms. The stages in the design thinking process such as empathising, which entailed understanding home, school, or community needs; problem finding (scoping possible topics based on the STEAM research and innovation agenda); deciding on the focus of the project; and creating and testing prototype solutions ensured innovation in the classroom. Another factor that was observed in the development of the curriculum is its alignment with the existing curricula of the Department of Education for two SHS subjects for the STEM strand, namely: *Inquiries, Investigations, and Immersion* (applied subject) and *Capstone Project* (specialised subject).

Monitoring and evaluation activities

In support of the year-long curriculum implementation, various professional development sessions for teachers, hackathons for students, brownbag sessions on technopreneurship and agricultural innovations, parent education seminars on STEAM, and dialogues with local government leaders on building innovation hubs were conducted.

Pre-tests and post-tests were carried out to assess student learning outcomes such as STEM career readiness (Barnachea & Paderna, 2019) (Appendix), metacognitive awareness (Shraw & Dennison, 1994), grit (Duckworth & Quinn, 2009), growth mindset (Dweck, 1999), and resilience (Smith et al., 2008).

STEAM innovation competition

To spark public interest and support for STEM, as well as plant the seeds for an innovation mindset, the programme culminated in a STEAM Innovation Competition that showcased students' outputs. The original plan was to involve

families, young children, local government officials, and other community members in a Community Expo. However, since the COVID-19 pandemic struck, the CISTEM decided to pivot the expo into an innovation competition. For their entries, students were asked to submit explanatory videos of their innovation as well as a digital poster that presents the materials and methods, results and discussion, and conclusion of the research. There were a total of 94 entries spread over the following categories: Agricultural Technology, Life Science, Material Science and Innovation, and Physical Science.

The locale: Sorsogon, Philippines

The STEAM Innovation Programme is implemented in Sorsogon, one of the provinces in the Bicol Region. It is the major producer of pili kernel and a major supplier of fish food in the region. Its agricultural products are among the top priority products of the Department of Trade and Industry (DTI) for agribusiness development. Despite its rich agricultural context, the poverty incidence among families in Sorsogon was reported at 46.2% in 2015 that declined to 26.1% in 2018 (NEDA Region V, 2020). The reason for having more than a quarter of families living in poverty was attributed to its vulnerability to natural hazards such as typhoons, flooding, and volcanic eruption and security threats due to insurgency.

Sorsogon province has 13 public SHS that offer STEM. Twelve of these schools are managed by the Department of Education, while one school is the laboratory school of the local state university.

Initial results of the programme implementation

In January 2019, the Undersecretary of the Department of Education for Curriculum and Instruction and the public school officials of Sorsogon, its superintendents, education programme supervisors, and school principals entered into an agreement to implement the year-long STEAM Innovation Programme in partnership with Unilab Foundation and faculty members from the University of the Philippines-Diliman, College of Education. It was the first of its kind multi-component STEAM innovation programme in the country that involved the community, families, school officials, teachers, and students in various capacity-building opportunities.

Roundtable discussion for defining the STEAM research and innovation agenda

In March 2019, a roundtable discussion (RTD) was conducted involving 70 local community stakeholders of Sorsogon. Participants were school principals, barangay officials, local business owners (e.g., pili oil companies, honeybee farms, pineapple growers, agricultural feed corporations), and representatives from local government agencies such as City/Municipality Planning Offices, Department of Agriculture, Department of Trade and Industry, and Department

of Environment and Natural Resources. The RTD aimed to introduce the STEAM Innovation Programme to local community stakeholders and consequently engage them in advancing STEAM education in Sorsogon. During the event, the attendees discussed community and local business needs that were potential areas for STEAM research and innovation in SHS. They also identified forms of support that could be extended to the students, teachers, and schools. Problems that emerged from the RTD included the following: Poor water supply for agricultural activities, limited knowledge on irrigation techniques, traditional farming practices, poor processing of local products, and low interest of the youth in agriculture. An FGD involving some of those present in the RTD was conducted to validate the research and innovation agenda for SHS. The problems that were raised in the RTD and the FGD were considered in the development of the STEAM Research and Innovation Agenda for SHS.

STEAM research and innovation agenda for senior high school

A community needs assessment tool was administered to 486 Grade 12 STEM students. The tool was parallel to the questions that were used in the RTD with local community stakeholders. The tool collected information about common problems that are encountered by students at home, in their school, and in their community. The students were asked to list three common problems at home and in school that need immediate solutions. They were also asked to interview at least two members of their community/*barangay* about problems of the community.

The STEAM Research and Innovation Agenda was culled from the community needs assessment tool that was administered to Grade 12 STEM students and from the outcomes of the RTD and FGD with community stakeholders. Major issues that had been identified in the research and innovation agenda were as follows: Surplus of local produce, innovations without patents, poor weaving skills of the young generation, water irrigation, traditional farming practices, reliance on seasonality of crops, lack of promotion of organic fertilisers, high farming expenses, pest infestations, poor processing of local produce, lack of after-harvest facilities, poor marketing strategies, and conversion of agricultural lands. Problems on disaster risks, connectivity, environmental protection, pollution, sanitation, lack of resources, and safety and security had also been raised. The agenda would be used by teachers and students in identifying problems for their STEM capstone project.

Design thinking workshop for STEM teachers

On May 6–8, 2019, a total of 108 teachers were taught to use the design thinking process for guiding STEM students to generate innovative projects. Teachers were introduced to ideation techniques, invention algorithms, prototyping, and innovation pitches that can be readily implemented in SHS classes. Teachers were also oriented on how to implement the innovation-focused curriculum for their STEM subjects in SHS. Table 7.1 shows Weeks 4–6 and 7–9 of the innovation-focused curriculum.

Table 7.1 Weeks 4–6 and 7–9 of the innovation-focused curriculum

<i>Week</i>	<i>Learning outcomes</i>	<i>Topics</i>	<i>Essential/key questions</i>	<i>Teaching/learning activities</i>	<i>Suggested assessment tools</i>
4–6	• Explain the importance of empathising in the Design Thinking Process • Use empathising strategies for different phases of the Design Thinking Process	<u>Empathise</u> • Aristotle's 7 Elements of a Good Storytelling • What-How-Why Method • Building Empathy with Analogies • 5 Whys • Conducting an Interview with Empathy • Empathy Map	• Why is the Empathise phase important in the Design Thinking Process? • How may each empathising strategy be used for the different phases of the Design Thinking Process	• Activity 1: When Red Balloons Fly • Activity 2: Shrek 2 • Activity 3: Using Analogies • Activity 4: 5 Whys • Activity 5: Conducting an Interview with Empathy	• Activity sheets • Rubric to evaluate group outputs
7–9	• Discuss the importance of problem finding • Use appropriate strategies to identify problems in various contexts	<u>Define (Problem Finding Strategies)</u> • Understanding Contexts • Invitational Stems • Looking at a Problem from a Different Perspective • Thinking of Possibilities and Alternatives • Remixing Words • Bubble Mapping	• Why is it important to learn how to find the right problem for STEM research? • What strategies can be used to identify problems in various contexts?	• Activity 1: My Home, School, and Community • Activity 2: What-If • Activity 3: Be a Bubble Maker	• Activity sheets • Instrument to evaluate group outputs

Table 7.2 Summary of evaluation for the design thinking workshop ($n = 98$)

<i>Item</i>	<i>Mean rating</i>
1 The objectives of the workshop have been attained.	4.88
2 The content of the workshop is relevant to STEM teaching.	4.99
3 The content of the workshop is timely/up-to-date.	4.91
4 The sessions are logically sequenced.	4.91
5 The allotment for each session is reasonable.	4.41
6 The facilitators are knowledgeable on the topics.	4.96
7 The flow of the workshop is systematic.	4.86
8 Workshop materials are well-provided.	4.88
9 Overall evaluation.	4.92
Average Mean Rating	4.86

Additionally, overall evaluation of the workshop (Table 7.2) showed very high satisfaction from the participants with an average rating of 4.92 (with 5 being the highest).

Implementation of the innovation-focused curriculum

In the course of the implementation of the innovation-focused curriculum in schools from June 2019 to February 2020, parent education seminars, continuing professional development sessions for teachers, hackathons for students, online community/curated resources, and dialogues with local government officials regarding an innovation hub were conducted.

It was in March 2020 that the programme was set to culminate in a Community STEAM Expo with the students presenting their research and innovation outputs. There were 94 abstracts submitted for the expo, which were categorised into: (1) Agricultural Technology, (2) Material Science and Innovation, (3) Life Science, and (4) Physical Science. Twelve abstracts per category were selected to advance to the next round. However, the COVID-19 pandemic happened and the Community STEAM Expo had to transition online.

The first communication with DepEd Sorsogon Province and DepEd Sorsogon City regarding the transition of the Community STEAM Expo to an online competition was in May 2020. The 48 qualifying teams were requested to send video presentations and digital posters as entries. Each qualifier submitted a five-minute video presentation to CISTEM, Inc. There were three winners from each category. Non-qualifiers of the contest category automatically competed for the digital poster category, and likewise, three teams were awarded as winners. Winners were announced through CISTEM's Facebook page on July 24, 2020. All the 13 participating STEM schools received an Arduino set of six kits as part of the sustainability plan.

The panel of judges included: Judge 1, an assistant professor of biology education of the University of the Philippines College of Education; Judge 2, a master teacher in a public elementary school; Judge 3, a process innovation specialist in

a telecommunication company; Judge 4, a research assistant in a water research and management laboratory of the University of the Philippines; Judge 5, a chemistry research laboratory supervisor; Judge 6, a science research specialist in the Industrial Technology Development Institute of the Department of Science and Technology; and Judge 7, a community lead of the UPSCALE Innovation Hub, University of the Philippines – Diliman.

Following are takeaways of some of the judges:

I realised with great delight that our students, at a young age, could be very much involved in working out community problems by innovating through design thinking. After the members persevere with the necessary iterations, I hope that their humble projects will become recognised and used across Sorsogon and beyond. – Judge 1

I was truly amazed with the outputs of the students, especially the videos. I can see from their works, all the hard work, creativity, and teamwork they've put in their projects. I also admire the fact that they were able to identify common problems in their community and provide recommendations that are feasible and effective. This only proves that with the right avenue and support from the teachers/school, our students can already provide solutions and make an impact to the community. Hope they will continue what they've started, and that there will be more people supporting these kinds of initiatives to help these students further improve their projects. All the best! – Judge 3

This has been a great learning experience for me not only about the recent researches our young scientists undertake nowadays but also about the vast and rich resources of Sorsogon (e.g. pili, mandarin, balimbing, tawa-tawa, bawang, etc.) that they tried to utilise in their studies.

Also, it is interesting how these young scientists carefully approached their goals through the scientific method and analysed their results with the correct statistical tools. Their creativity in creating their video presentations and digital posters while trying to present their research in a systematic manner is also noteworthy. – Judge 5

It is very fascinating to know that students from Sorsogon practices their creativity using science in order to address various concerns in their community. As a researcher and scientist, I am a firm believer of the great impact of science if applied in terms of various technologies towards the enhancement of human lives. Continue to explore the effects of science and how it can affect our way of living. – Judge 6

Based on the takeaways from the judges, they appreciated the involvement of students in solving community problems by innovating through design thinking. They saw great potential in the programme that provided opportunity for the students to generate feasible and effective solutions that make an impact on the community. They recognised that hard work, perseverance, creativity, and teamwork were evident in the outputs of the students and that the rich local resources were investigated further through the programme.

Future directions

Although the pre-tests were administered at the start of the School Year 2019/2020 in June 2019, administration of post-tests was delayed. This is because classes were suspended in March 2020, and community quarantine was imposed in most parts of the Philippines. Nonetheless, the tests were converted to Google forms and administered online. Collection of responses was recently completed with the data needing to be processed. Test results will then be analysed to determine the effects of the innovation-focused curriculum on students' STEM career readiness, metacognitive awareness, grit, growth mindset, and resilience.

Furthermore, all the components of the programme will be redesigned based on the evaluation results for the sustainability and scalability of the programme. Curriculum guides will be recalibrated and submitted to the Department of Education, Bureau of Curriculum Development for adoption and implementation in other SHS offering STEM. On the other hand, engagement with the STEM teachers will continue through additional professional development activities covering other topics on research and innovation. The experience of the pandemic and subsequent community quarantines brought to light problems on food insecurity and involuntary hunger that are linked to loss of jobs. In response to the said need, the STEAM Innovation Programme will be redesigned to incorporate the development of innovative solutions to combat food insecurity. With the additional component of the programme, the expertise of the Department of Agriculture – Agricultural Training Institute will be tapped, thereby, strengthening inter-sectoral collaborations. Furthermore, since students are staying at home because of the remote learning delivery for the current school year, home-based and community-based innovations will be encouraged.

In terms of the learning resources, the programme will embark on both offline and online materials. Additional materials will have to be developed in consideration of the new delivery modes. Suitable technology platforms will also be explored to support the new setting. Because of restrictions on travelling and gathering, the hackathon, which used to be in-person, will be done through an online platform. The new setup will allow for more mentors to be involved without being constrained by distance, which means that local and international experts can assist the students in their projects. This will consequently grow the innovation ecosystem that the programme wishes to establish with greater participation from government, industry, and other academic institutions.

Conclusion

It was in 2016 that the first batch of SHS students in the Philippines enrolled in their respective schools with more than one million Grade 11 students (Geronimo, 2016; Mateo, 2016). Based on the pre-registration data of the Department of Education as of May 2016, a month before the start of classes for the first batch of SHS students, only 8% of the total number of students

had signed up to take up the STEM strand while the majority (40%) followed the technical-vocational track (Banal-Fermoso, 2016). However, in 2018, it was reported that there was a 60% increase in the number of students who developed an interest in STEM throughout the years (Genimiano, 2018). According to studies, students who pursued STEM strands in high schools were significantly more likely to be in a STEM bachelor's degree programme after high school graduation (Means et al., 2018) which is a good manifestation of the improvement in STEM education.

Qualified STEM professionals are needed to remain economically competitive in the global market and to fill contemporary demands such as ensuring sufficient and sustainable energy, efficient healthcare, and well-considered technology development (Bøe et al., 2011). It is estimated that “65% of children entering primary school today will ultimately end up working in completely new job types that don't yet exist” (World Economic Forum, 2016, p. 1). In the Philippines, some of the emerging job roles include software and applications developers and analysts, data analysts and scientists, financial and investment advisers, and database and network professionals (World Economic Forum, 2018). Although Sorsogon is an agricultural province, a considerable number of students' research and innovation projects shows direction toward the said emerging jobs.

A STEAM Innovation Programme is critical in creating a culture of innovation and collaboration. To facilitate its full implementation, important components of such programmes are consultation with stakeholders, teacher capacity-building, an innovation-focused curriculum, learner empowerment, parent education seminars, curated resources, and community expos. A programme redesign is also warranted to ensure its sustainability and scalability. The redesign will include digital conversion of materials and other resources for remote learning delivery, online capacity-building workshops, virtual hackathons, an online community of practice (for teachers and students), and assistance for technology transfer or business development for winning projects.

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Appendix: Assessment Tools

Stem Career Readiness Scale

Source: Barnachea, A. and Paderna, E.E.S. (2019). *STEM Career Readiness Scale*. Philippines: University of the Philippines-Diliman, College of Education.

Directions

For each statement, you will have to choose the degree (Strongly Disagree, Disagree, Agree, and Strongly Agree) to which the statement applies to you. Encircle the letter (SD, D, A, SA) corresponding to your answer. Think about each statement independently from other statements. Do not be influenced by your answers to other statements. There is no right or wrong answer. Please respond to all statements.

	<i>Strongly disagree (SD)</i>	<i>Disagree (D)</i>	<i>Agree (A)</i>	<i>Strongly agree (SA)</i>
Science process skills				
1 I am a keen observer.	SD	D	A	SA
2 I can easily compare objects based on their characteristics.	SD	D	A	SA
3 I can measure with great precision and accuracy.	SD	D	A	SA
4 I can conclude based on observations and facts.	SD	D	A	SA
5 I can identify what variables I need to use in my experiments.	SD	D	A	SA
6 I can predict the relationships between variables.	SD	D	A	SA
7 I can discuss results.	SD	D	A	SA
8 I cannot formulate a hypothesis.	SD	D	A	SA

(Continued)

	<i>Strongly disagree (SD)</i>	<i>Disagree (D)</i>	<i>Agree (A)</i>	<i>Strongly agree (SA)</i>
9 I can test hypothesis using experiments.	SD	D	A	SA
Mathematical skills				
1 I can easily understand mathematical concepts and formula.	SD	D	A	SA
2 I can perform mathematical operations (<i>e. g. addition, subtraction, multiplication, and division</i>) with great accuracy.	SD	D	A	SA
3 I am able to use the appropriate formula based on what the problem asks.	SD	D	A	SA
4 I can derive a formula from another formula.	SD	D	A	SA
5 I enjoy solving math problems.	SD	D	A	SA
6 I can explain with confidence how I came up with my answer.	SD	D	A	SA
7 I can defend my solution if I need to.	SD	D	A	SA
8 When I find it hard to solve a math problem, I see it as a challenge and won't give up.	SD	D	A	SA
9 I know how and when I can apply Mathematics in daily-life problems.	SD	D	A	SA
Critical thinking				
1 I think of possible results before I take action.	SD	D	A	SA
2 I can make conclusions after observing and gathering facts.	SD	D	A	SA
3 I only make assumptions based on the information given.	SD	D	A	SA
4 I develop my ideas by gathering information.	SD	D	A	SA
5 When facing a problem, I identify options.	SD	D	A	SA
6 I can assess if a statement is logically correct based on information given.	SD	D	A	SA
7 I am able to support my opinions with valid information.	SD	D	A	SA
8 I cannot identify which information is relevant to solve a problem.	SD	D	A	SA
9 It is important for me to get information to support my opinions.	SD	D	A	SA
10 I can distinguish if an argument is strong or weak.	SD	D	A	SA

(Continued)

	<i>Strongly disagree (SD)</i>	<i>Disagree (D)</i>	<i>Agree (A)</i>	<i>Strongly agree (SA)</i>
ICT skills				
1 I use valid internet sources to research for information.	SD	D	A	SA
2 I utilise social media to share valid information.	SD	D	A	SA
3 I can select technological resources to accomplish work productively.	SD	D	A	SA
4 I organize my files in my computer.	SD	D	A	SA
5 I name my files in an orderly way so that I can easily search them when I need them.	SD	D	A	SA
6 I can evaluate if an article came from a valid source.	SD	D	A	SA
7 I only share information after validating it.	SD	D	A	SA
8 I think that intellectual property rights should be taken seriously.	SD	D	A	SA
9 I do not use technology to threaten other person.	SD	D	A	SA
10 I do not practice proper citations when using references.	SD	D	A	SA
Work ethics				
1 I show honesty in my words and actions.	SD	D	A	SA
2 I can be objective in dealing with people and situations.	SD	D	A	SA
3 I believe that I can be trusted with vital information.	SD	D	A	SA
4 If I have issues with someone, I talk to them directly.	SD	D	A	SA
5 Before I make a decision, I consider the pros and cons.	SD	D	A	SA
6 I know when it is appropriate to listen and when to speak.	SD	D	A	SA
7 I do my best in every task that is entrusted to me.	SD	D	A	SA
8 I cannot motivate my group mates to achieve a common goal.	SD	D	A	SA
9 I will not do anything that will harm my reputation.	SD	D	A	SA
10 I take full responsibility for my actions.	SD	D	A	SA

Brief resilience scale

Source: Smith, B. W., Dalen, J., Wiggins, K., Tooley, E., Christopher, P., and Bernard, J. (2008). The brief resilience scale: Assessing the ability to bounce back. *International Journal of Behavioral Medicine*, 15, 194–200.

Metacognitive awareness inventory (MAI)

Source: Schraw, G., & Dennison, R.S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, 19, 460–475.

Mindset test

Source: Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality, and development*. Philadelphia: Psychology Press.

Short grit scale

Source: Duckworth, A. and Quinn, P. (2009). Development and validation of the short grit scale (Grit-S). *Journal of Personality Assessment*, 91(2), 166–174.