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Article *in* Philippine Journal of Science · June 2020

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Philippine Journal of Science
149 (2): 415-426, June 2020
ISSN 0031 - 7683
Date Received: 13 Dec 2019

Self-professed Proficiency of Philippine Higher Education (PHE) Teachers of STEAM Disciplines

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This study determined the self-professed proficiency of Philippine higher education (PHE) teachers of science, technology, engineering, agri/fisheries, and mathematics (STEAM) disciplines. Through the lens of technological pedagogical content knowledge (TPACK) framework and the standards of teaching the disciplines in STEAM in advance and higher learning as spelled out in the indicators of proficiency used in this research, the study informed the status of teacher quality in the different disciplines of STEAM. Sampled (Tier 1: stratified random sampling for 156 schools; Tier 2: complete enumeration) 1940 teachers (representing the different STEAM disciplines) took the online survey in January–December 2018. Selected teachers from the set provided interviews and classroom observations for data triangulation. Data analysis (*i.e.* programmed scoring framework, descriptive statistics, percentile rank, and t-test) determined that self-rated proficiency defined their competence. In terms of the aforementioned framework and standard, they perceived themselves as "Highly Proficient to Distinguished" teachers. The qualitative data worked with these findings, but some coupled with student achievement (through licensure performance) revealed that teachers may have over-rated themselves. Males and females do not register significant differences in their perception of proficiency. School type (private and government-owned) do not index significant differences as well, except in Community Linkages and TPACK as a whole. These findings may inform policy creation to build a stronger Philippine Workforce 4.0. In fact, the tool (proficiency instrument) may be envisioned to initiate a highly structured micro-credentialing system of STEAM education in the country.

Keywords: proficiency level, self-perception, STEAM (science, technology, engineering, agri/fisheries, mathematics), STEAM education, teacher quality, TPACK (Technological Pedagogical Content Knowledge) framework

INTRODUCTION

"New Collar Workforce" or Workforce 4.0 is the new buzz to describe the 21st-century workers (Biosvert 2008). This description wipes off the delineation of white and blue collar labor and focuses on new skills that Generation Z (present tertiary students aged between 18–23 years old) (Fisk 2017) should develop. Inclusively, the projected human resource needs to imbibe the new skill set (*e.g.* critical and creative thinking, design thinking, problem-solving thinking, entrepreneurial thinking, social consciousness thinking) to attune to the "global workforce transformation" (Goldsberry

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2018). This labor force projection ultimately meets the Industrial Revolution 4.0 (IR4.0) where the market expects the workforce to harness the emerging digital operations waves (*e.g.* the use of artificial intelligence and the Internet of Things). Evidently, this human resource landscape requires a new education blueprint that shifts the current education paradigm (Education 3.0 – "technology era") to the envisioned education archetype (Education 4.0 [E4.0]). This vision will fully cater to the needs of the "innovative era." Thus, a countrywide campaign to imbibe the perspectives of E4.0 spelled out in the Philippine Development Plan (PDP) drives all sectors of the government to strategize for progress (NEDA 2017). Specifically, significant changes in all levels of education envision global goals (*e.g.* IR4.0, economic growth) through technological advancement, and research and innovation. As a matter of fact, NEDA (2017) also defines the acceleration of human capital as a strategy to emphasize developing the attributes and qualities of skilled professionals (in the different STEAM disciplines) (CHED 2019). As such, the need for quality teachers arises as the key element to deliver the aforementioned disciplines and curricula according to global and national standards.

Connectedly, teacher quality – in general – is defined as what teachers should know and be able to do within and during societal change and transformation (NRC 2001). This circumstance fuels the government to invest in assessing, reskilling, and monitoring the teaching force in the different disciplines clustered as STEAM (collectively called STEAM disciplines, and teachers as teachers in the STEAM disciplines) to leverage them to the new landscape. Thus, this study focuses on assessing the PHE teachers' (in the STEAM disciplines) proficiency in teaching their respective courses. By STEAM disciplines, this study focuses on the different disciplines that CHED has identified under such category/cluster (please refer to https://ched.gov.ph/?s=STEAM), and the term 'teachers in the STEAM disciplines' refers to teachers teaching their respective disciplines within STEAM.

Towards E4.0

The new vision of learning (E4.0) features learners learning the skills and the know-how of sourcing these skills and knowledge. In fact, Fisk (2017) believed that learning in this era emphasizes the collaboration of "men and machines", and "lifelong learning" that will enable new possibilities for a globally-bonded and technology-driven environment. Thus, ways and means to achieve a full-proof Workforce 4.0 through E4.0 embody concepts and theories in full gears. Countries around the globe embark on this pursuit to flawlessly establish this education blueprint (*e.g.* Schule 4.0 of Austria, Malaysia 4.0, Thailand 4.0). Their strategy for digital education concentrates on all domains of education such as pedagogy, tools and technology, curriculum, assessment, and digitally competent teachers.

Similarly, country-wide initiatives for reskilling and upskilling of teachers may suit the current condition of the Philippine human resource. To note, out of the 3,589,484 tertiary enrollment in the year 2019, only 38.5% chose disciplines under STEAM. The country only benefits from about a 20% completion rate in state universities and colleges (SUCs), and an average of 21.9% completion rate for STEAM (CHED 2019). Although these data sets exclude exemplar achievements of universities tagged as COEs (centers of excellence) and CODs (centers of development) in the disciplines of STEAM, the aforementioned condition is aggravated by the low rate of completion in the different STEAM disciplines (15–27% of the entrants in the other HEIs) that outlines a negative outlook on how the country may utilize STEAM professionals (professionals who graduate from any of the aforementioned STEAM disciplines) for its knowledge capital (CHED 2019). Thus, the government launched its five-year PDP (2017–2022) to bring the country to the global mark. This country-wide initiative forges collaborations among agencies to achieve better global metrics. The programs of the Department of Science and Technology (in partnerships with other agencies) for the accelerated human resource has already reaped a 19-mark rank improvement (from 73rd to 54th) in the 2019 Global Innovation Index. The education sector also exemplifies such efforts by proliferating the concept of E4.0 as a means towards IR4.0. Relatively, CHED puts the STEAM disciplines at the forefront of this effort as a bold move to improve the current global metrics of the country.

From STEM to STEAM

Tracing back, STEM is a global icon for programs in the sciences, technology, engineering, and mathematics because of the increasing national and international focus that its advancement propels economic growth and progress (English 2016). STEM is more than just an acronym for the four major fields, though. In fact, first world countries (the USA, Australia, plus countries in Europe) teamed STEM with an "A" for the Arts in the belief that "disciplines are stronger together than they are apart." Additionally, STEAM as a new education framework calls for the development of skills that students will eventually use in the workplace such as the ability to work with others, verbal communication, creative and critical thinking, active listening and active learning, and a disposition towards lifelong learning – deemed important in IR4.0 (Infosys 2016). To note, STEAM definitions have evolved into a new interdisciplinary education approach to learning that utilizes the five disciplines. Such a big responsibility as a framework lies in the shoulders of the teachers; thus, it has compelled much research on teaching competency enhancement.

In the Philippine context, the concept of STEM boosted K to 12 senior high school (SHS) curriculum. This enhancement of the basic education program labeled STEM as a curricular track for all SHS students preparing to take a collegiate degree in any of the STEM disciplines. However, CHED deviated from the Department of Education's vision for STEM and pursued instead clustering the disciplines as STEAM, emphasizing A as agri-fisheries courses (CHED 2019).

Connectedly, the study aimed to provide initial actions in building teacher quality by looking into the self-professed proficiency, and other observed or manifested features in teaching their respective disciplines in the collegiate level. This study theorizes that the PHE teachers in the STEAM disciplines permeate unique proficiency in teaching their respective disciplines defined by theories influencing the higher education curricula as mandated by the Philippine government through CHED's policies, standards, and guidelines (PSGs). These driving forces that outlined the disciplinal curricula included CHED's PSGs for each discipline, TPACK framework, and the standards of tertiary teaching as spelled out in the indicators of proficiency used in this study (Morales *et al.* 2019).

In this study, revised PSGs based on the outcomes-based education framework spelled out all the requisites including the disciplinal curricula, and recruitment policies and criteria for teachers of specific disciplines in STEAM. Weaving such with the standards of tertiary teaching presents a visual of teacher quality of teachers in the STEAM disciplines at the collegiate level. Specifically, these standards of tertiary teaching are clustered into seven domains, as presented in Appendix Table I.

TPACK focuses on how teachers intertwine and integrate their knowledge in technology, pedagogy, and content in delivering any lesson (Mishra and Koehler 2006). Weaving all the aforementioned frameworks, policies, guidelines, and standards deduced a significant TPACK framework of proficiencies and competencies that guided the study in determining the PHE teacher quality (of teachers in the different disciplines of STEAM) through their self-professed proficiency and other manifested attributes. Specifically, the study sought the attainment of the following objectives:

1. determine the self-professed proficiency of PHE teachers in the different disciplines of STEAM in terms of domains of the standards of tertiary teaching, and TPACK dimensions; and
2. determine the significant difference in the teachers' proficiency in terms of (a) gender and (b) school type.

MATERIALS AND METHODS

Research Design

The study employed a descriptive design using a combination of quantitative method (a survey), and qualitative methods (interview and classroom observation) to gather information and describe the self-professed proficiency of PHE teachers in the STEAM disciplines in teaching their respective disciplinal content in the collegiate level. The study encompassed the entire archipelago to provide thorough documentation and rich details of teachers' self-professed proficiencies.

Instrument

The study utilized the proficiency indicators for Philippine STEAM educators (Morales *et al.* 2019), and was administered online *via* Google Forms. This self-rating tool included 60 proficiency indicators clustered into the seven domains of learning (the focus of each are provided in Appendix Table I), and into the seven TPACK dimensions with overall internal reliability (Cronbach alpha) of .985. Each dimension registered an internal reliability within the range 0.75–0.93.

Classroom Observation Protocol for STEAM

This is a pack that contains five different instruments: 1) the classroom observation rating scale (a 48-item, six-point Likert scale tool), 2) classroom observation notes (includes questions clustered into the dimensions of TPACK designed for qualitative observations), 3) TPACK interview protocol (six-items having main questions with corresponding probing questions clustered according to themes, 4) technology integration checklist, and 5) assessment checklist. The six-point Likert classroom observation rating scale determines the extent of visibility of the identified traits, characteristics, processes, and products relative to content, knowledge, and pedagogy; the learning pedagogy; and the diversity of learners. The observation note is designed for use by researchers who would want to collect qualitative data on education in the disciplines of STEAM anchored on the TPACK framework.

Participants

With a set confidence level of 95% and from CHED data on the total population of Philippine higher education institutions (HEIs) (2299), about 220 HEIs (10% of the population) were randomly selected sourced from the 17 regions of the country. Based on percentage representation, 156 (71%) private schools and 64 (29%) public HEIs should comprise the participants of the proficiency survey. However, the call for participation generated a positive response from 123 schools (56% of the sample HEIs). Specifically, public HEIs included 46 Levels 1 or 2 SUCs, 20 local universities and colleges (LUCs), and 57 private institutions of higher learning. Complete enumeration (n = 1940) of teachers in the disciplines of STEAM in the identified schools are the focus of the proficiency survey. Specifically, 936 males and 1000 females comprise the entire data set (participants with implausible responses were deleted). In terms of school affiliation, 1219 teachers are connected with government-owned (SUCs and LUCs) HEIs and 635 from private colleges and universities. From the initial sample size (n = 1940), 106 teachers from the 17 regions of the country were selected for classroom observation and interviews. As per CHED (2016), SUCs Levels 1 and 2 satisfy less than or the minimum points in each of the key results area (KRA1: quality and relevance of instruction, KRA2: research capability and output, KRA3: services to the community, and KR4: management of resources) that label them as teaching universities. The list did not account for COEs and CODs of STEAM, which are considered research-universities. Furthermore, these sampled teachers are recruited in their respective institutions and promoted based on the recruitment policies of their respective HEIs that conform to the respective PSG requirements of their discipline. As per educational attainment, 24% are Ph.D. graduates, 47% are master's degree graduates, and 28% are bachelor's degree holders. The availability of the teachers on the scheduled visits, and their willingness to undergo classroom observation and interviews were the main considerations in choosing them.

Data Collection

Pre-survey. Prior to the survey, letters were sent to the sampled HEIs. Once the target HEI accepts the invitation to participate, correspondence to the HEI-recommended research representative – who is referred to as the "field researcher" – for a virtual (SMS, phone call, email) orientation of his/her corresponding tasks commenced. The field researchers were asked to enumerate and profile all the sampled teachers in their institution. Then, templates were sent for correspondence to the enumerated teachers through the field researchers. Each field researcher requested (via email, SMS, or personally) the identified respondents to respond to the online survey. As a precaution, the field researchers also sent emails to the respondent stipulating that the online survey must be accomplished within a specific time frame.

Before classroom observations and interviews, a notice of the visit was sent to the school head or university president of the HEI through the field researcher. This notice stipulated the request to accomplish the set of forms that includes: 1) the participating institution's reply form specifying the time and day or date of the interviews and classroom observations, 2) pre-observation questions (which should be accomplished by the recommended teachers prior to observation), 3) technology integration and assessment checklist, and 4) session guide. These are accomplished forms sent for confirmation of the data collection tasks in the identified HEI.

Survey. The survey commenced on 15 Jan 2018 and concluded on 30 Dec 2018. A letter of consent was embedded in the first part of the survey to immediately close the survey system in case the suggested teacher does not agree to respond to the online survey. Furthermore, the system can and will open to the next part once the participant agrees to respond to the online survey. The field researchers administered the survey to the respondents through an asynchronous "log in" to the web link. Once the majority of the respondents completed the survey, the field researchers finalized the list and sent the list of teachers who successfully responded to the survey call. To ensure a unique response per respondent, the email of the sender of the response (*via* Google Form) is matched with the registered email prior to the online survey. Note that only one email per respondent was accepted, registered, and submitted by the field researcher prior to the survey.

School/HEI visit. Prior to the scheduled visit, 106 selected teachers were asked to accomplish the technology integration and assessment checklists. The survey generated 86 responses for the technology integration checklist and 84 responses for the assessment checklist. Others were not able to submit or complete these checklists for certain reasons. A courtesy call was also conducted to the officials together with the field researcher upon arrival. Interviews started with the head of the department or the dean of the college of the different STEAM disciplines for about an hour. This interview was audiotaped or videotaped depending on the interviewee's choice.

Classroom observations were initiated after the interviews with the officials. Each of the sampled teachers was also observed in their respective classes in the entire allotted period, and a "post-conference" (an interview after the classroom observation) was conducted to clarify items in the tools, which were not observed to manifest during the observation. Classroom observations were audiotaped or videotaped depending on the choice of the teacher being observed.

Post-survey. The results of the survey were consolidated and the team subjected all generated data to the developed scoring program to determine their self-professed proficiency in teaching their respective disciplines.

Scoring and Data Analysis

Data sorting and subjecting of the data to the scoring program generated the proficiency level of the participants in terms of the seven domains of standards of tertiary teaching, the seven dimensions of TPACK, gender, and school type. The study used descriptive statistics and a test of significance to compare the proficiency levels of the sampled teachers in terms of gender and school type. For comparison purposes, all the domain scores were converted into standardized scores (S) ranging from 0–100 using the linear transformation equation S = (SR – LPR) x (100 / HPR) – where SR, LPR, and HPS represent the sum of ratings, lowest possible rating, and highest possible rating. The computations indicated that – on the average – 3.1% are Beginning, 8.1% Proficient, 38.4% Highly Proficient, and 50.4% Distinguished teachers. To simplify the process of determining the proficiency of the teachers, the identified percent count of teachers in the career stages (Beginning, Proficient, Highly Proficient, and Distinguished) was used to determine the score range for each level of proficiency. Using percentile ranking, it was identified that $P_{3.1}$ = 57.48, $P_{11.2}$ = 69.91, and $P_{49.6}$ = 85.28. This scheme enabled us to derive the following STEAM proficiency scale: Distinguished ($85.28 < S \leq 100$), Highly Proficient ($69.91\ S \leq 85.28$), Proficient ($57.48 < S \leq 69.91$), and Beginner ($0 \leq S \leq 57.48$). Descriptive statistics and the t-test for independent samples were used in comparing the proficiency levels of the sampled teachers in terms of gender and school type.

All recordings (interviews and classroom observations) were transcribed and the team also subjected all transcripts to a computer-based coding system. "Open coding" was conducted where specific lines or segments of the data were named by creating new codes (core codes), which were redefined in the succeeding phases of analysis. Then, "selective coding" (there were three more iterative cycles of coding) was implemented to define the most significant higher-level codes and sort the lower-level codes created during the initial coding phase creating hierarchically-grouped codes to design the "code tree."

RESULTS AND DISCUSSION

Self-professed Proficiency of PHE Teachers in the STEAM Disciplines

The sampled teachers' self-professed proficiency marks their adeptness to teaching and learning in terms of the seven domains of tertiary teaching standards and seven TPACK dimensions (Table 1).

As shown in Table 1, the majority (f = 978, 50.4%) of the participants perceive their overall level of proficiency as "Distinguished." Their high regard of themselves as teachers of their respective disciplines in STEAM as manifested in Domains 2, 3, 4, and 6 loads more than 50% of surveyed teachers. It seems that they tend to have a positive self-concept that may boost their self-confidence and self-esteem (Glotova and Wilhelm 2014), thus building positive attitudes towards teaching and learning. Their high concept of "me as an effective teacher" that manifests in specific domains further emphasize their positive self-concept to teaching and learning. This high regard for "the self" in these domains may be sourced from their dominant Filipino trait of being caring and loving, and giving importance to "*pakikisama* (fellowship) or *bayanihan* (collaboration)" tradition (Owlcation 2016).

It was also observed that the highest-registered percentages were in Domains 3 and 6, emphasizing learner diversity and the community. This result shows that they consider the differences among their students and adjust their practices according to the needs of the learners whom they encounter. For instance, one interviewed teacher-participant emphasized that she always bears in mind the varied ability levels of her students, "some of them are already familiar with the concepts… some do not have ideas," to a point where she provides "extra time to students who need special attention" and requires them to attend "special sessions so that they can level up with their classmates." Teachers also recognize that even if they are teaching in higher education (tertiary level) that "one method will not work with everybody," hence the notion that they "have to be diverse with [their] methods" to address the varying needs of the learners still applies.

Similarly, the value that teachers give to their community partners is very evident through partnerships and collaboration. They consult related industries in crafting their curriculum ("for the formulation of prospectus or curriculum… we invite students and stakeholders from different industries"), and in assessing their students ("we invite industry partners and we also collaborate for us to really check [the performance of students]… we also have evaluation forms for the [industry] supervisors to really evaluate our OJTs [on-the-job training students]"). Teachers also involve the community in the teaching and learning process, research, and extension activities. One teacher shared, "we have community-based research and community extensions wherein students can apply their learnings and share them to the community." Another case is given by an Information Technology teacher, "we require them [students] as a capstone project to look for possible problems in the industry and then ask them to develop a system – an information system – to address that problem."

Table 1. Frequency of teachers in each career stage of the domains in the standards for tertiary teaching (n = 1940).

	Domain	*M*(*SD*)	Beginner	Proficient	Highly Proficient	Distinguished
		[Level]	*f* (%)	*f* (%)	*f* (%)	*f* (%)
Domains in the Standards of Tertiary Teaching	Domain 1: Content Knowledge, and Pedagogy	78.27 (*14.26*) [HP]	146 (7.5)	354 (18.2)	739 (38.1)	701 (36.1)
	Domain 2: Learning Environment	84.99 (*13.02*) [HP]	56 (2.9)	144 (14.4)	700 (36.1)	1040 (53.6)
	Domain 3: Diversity of Learners	87.83 (*12.58*) [D]	62 (3.2)	82 (4.2)	474 (24.4)	1322 (68.1)
	Domain 4: Curriculum and Planning	84.53 (*13.00*) [HP]	74 (3.8)	191 (9.8)	585 (30.2)	1090 (56.2)
	Domain 5: Assessment and Reporting	82.01 (*16.66*) [HP]	135 (7.0)	241 (12.4)	728 (37.5)	836 (43.1)
	Domain 6: Community Linkages and Professional Engagement	84.44 (*13.93*) [HP]	97 (5.0)	120 (6.2)	582 (30.0)	1141 (58.8)
	Domain 7: Personal Growth and Professional Development	83.64 (*15.32*) [HP]	122 (6.3)	120 (6.2)	780 (40.2)	918 (47.3)
	Overall	**83.67 (*11.83*) [HP]**	**60 (3.1)**	**157 (8.1)**	**745 (38.4)**	**978 (50.4)**
TPACK Dimension	TPCK	85.36 (*12.41*) [D]	66 (3.4)	138 (7.1)	582 (30.0)	1154 (59.5)
	TPK	84.71 (*12.38*) [HP]	56 (2.9)	124 (6.4)	720 (37.1)	1040 (3.6)
	TCK	72.61 (*17.75*) [HP]	355 (18.3)	416 (21.4)	657 (33.9)	512 (26.4)
	PCK	81.63 (*13.21*) [HP]	104 (5.4)	208 (10.7)	765 (39.4)	863 (44.5)
	TK	81.82 (*17.59*) [HP]	184 (9.5)	214 (11.0)	501 (25.8)	1041 (53.7)
	PK	87.43 (*11.46*) [D]	33 (1.7)	112 (5.8)	570 (29.4)	1225 (63.1)
	CK	83.14 (*15.59*) [HP]	83 (4.3)	240 (12.4)	724 (37.3)	893 (46.0)

Contrastingly, although nearing half of the sampled teachers believe they are "Distinguished," more than half thinks otherwise (view themselves as beginners to highly proficient) in Domains 5 (assessment and reporting) and 7 (personal growth and professional development). Comparing with the aforementioned domains, the majority appraises assessment and reporting – specifically formative assessment (El-Kafafi and Cha 2016) – as not so well explored, probably due to teacher difficulties in this domain. As shown in Appendix Figure II, more teachers tend to favor traditional forms of assessment rather than authentic types. A probable reason for this is the lack of training and unavailability of the technology needed to implement other forms of assessment. Thus, this construct (assessment and reporting) may be needing enhancement through professional training, which may address cohering their practices with assessment principles, and improving their self-concept as well. For personal growth and professional development, opportunities and support are also limited and, usually, faculty members take turns in attending educational conventions ("training is costly… it should be distributive [distributed among faculty members]… *kung ikaw pumunta ka sa ganito, dapat iba naman sa ganyan* [if you attended this, then another should attend that]").

Only Domain 1 (content knowledge and pedagogy) reports the highest percentage distribution of the sampled teachers in "Highly Proficient" career level. Apparently, the surveyed teachers' lower than "Distinguished" self-assessment in this domain may be sourced from the percentage distribution (on the average) of their respective degrees, implying that almost a third of them have not yet completed their post-baccalaureate degrees in their respective fields/disciplines that presents low self-assessment in content knowledge.

In terms of their self-concept in TPACK dimensions, the sampled teachers regard themselves as "Distinguished," with strong consideration of the "Distinguished" appraisal in TK and PK that match their self-views in other domains (TPK, PCK, TCK) as "Highly Proficient." Relatively, they perceive a proper blend and balance (weave of three core components: CK, PK, and TK), and the significant role of technology in teaching as a manifestation of their self-concept in terms of TPACK dimensions (Mishra and Koehler 2006). Apparently, many teachers say they integrate technology to "make discussion more meaningful and to give students proper examples on how technology works in both theory and in application." However, Appendix Figure I shows that they tend to only favor technologies used for presentations, while only a considerable number of respondents integrate the use of movies and videos. As per the analysis, the low mean for TCK (Table 1) is indicative and suggestive that the teachers are still in the process of commencing technology integration in tertiary teaching. This is probably due to their experiences of having to deal with insufficient funding and financial support, lack of tools and equipment, shortage in manpower, digital illiteracy, and teachers' hesitance in learning the tools (Raman and Yamat 2014). Even though the interviewed teachers believe that the use of technology has the potential to "make class not boring and gain participation," the capability to "promote critical thinking," and the power to simulate "real-life applications;" they mentioned that they mainly consider "availability," "functionality," "practicality," "user-friendliness," "relevance and applicability to discussion," and "student access" in selecting technological tools to use in their classes. In sum, it may be inferred that among the three domains, there exists a maturity in pedagogy and even in the assessment domain, but a novice level in technology integration and the weaving of technology integration to assessment and pedagogical context.

Generally, teacher quality is acknowledged as a key element in uplifting education (Harris and Sass 2007) and a major factor in improving student performance (Sirait 2016). However, it is interesting to note that even though these sampled teachers appraised themselves highly in terms of domains of tertiary teaching standards, as well as TPACK dimensions, this doesn't seem to translate to their students' achievement and retention in the program. For instance, it can be observed in Appendix Table II that the passing rate in professional examinations (from 2014–2018) in STEAM areas (with licensure examination) is only 53.66%, where the ratings in technology, agriculture, and mathematics-related courses are below 50%. While these results may not be true to schools or universities tagged as COEs and CODs, sampled teachers in the study sourced from SUCs Levels 1 and 2, private, colleges, and LUCs (which are teaching universities) may well belong to schools generally rated in the aforementioned licensure ratings and results. It is also surprising to note that the completion rate across STEAM disciplines are all below 30% (see Appendix Figure III). A possible explanation for this is provided by Dunning and co-authors (2004), who claim that self-views hold only an insubstantial to a moderate relationship with their true behavior and performance and that people have a tendency to believe themselves to be above average. Additionally, they argued that people overrate or overestimate themselves. This implies that even though the sampled teachers view themselves as "Distinguished" or "Highly Proficient," this might not be the case in their actual practices and performance. Nevertheless, the results can still be used to provide evidence of quality teaching (for motivating students) and dedication (teachers genuinely enjoy teaching) to its improvement in the aforementioned school type from where the sampled teachers were drawn.

The further analysis draws more information in describing the proficiency level of PHE teachers in the STEAM disciplines. Commencing, the domain and dimension scores (sourced from the scoring framework) were standardized that eventually compare their self-professed proficiencies in terms of gender (Table 2) and type of school affiliation (Table 3).

Table 2 shows that there is no significant difference in the teachers' proficiency in terms of gender ($p = 0.142$). Specifically, five of the seven (71.4%) domains note no significant difference in the proficiency scores of males and females [Domain 1 ($p = 0.562$), Domain 4 ($p = 0.567$), Domain 5 ($p = 0.863$), Domain 6 ($p = 0.199$), and Domain 7 ($p = 0.459$)]. The comparison also reveals that the mean score of females is consistently higher than males, with the exception in Domain 1. Contrastingly, a significant difference was noted in the proficiency scores of male and female teachers in Domain 2 ($p = 0.033$) and Domain 3 ($p = 0.000$) in favor of the female. In the case of TPACK dimensions, it was observed that the mean self-rated proficiency scores of male teachers are higher in TCK, TK, and CK, whereas the mean proficiency scores of female teachers are higher in the domains TPCK, TPK, PCK, and PK. It was noted that there is no significant difference in the proficiency scores of male and female teachers in TPCK ($p = 0.093$), TCK ($p = 0.160$), PCK ($p = 0.385$), TK ($p = 0.150$), and CK ($p = 0.196$); whereas a significant difference is found in TPK ($p = 0.018$) and PK ($p = 0.000$) domains.

The mark difference of self-concept in Domain 2 (learning environment) suggests that female teachers demonstrate a stronger demand for a safe, secure, fair, and supportive educational atmosphere to promote learner responsibility and achievement. For instance, a female science teacher narrated that she habitually "give an orientation about

Table 2. Domains of tertiary teaching standards and TPACK proficiency comparison between gender.

		***M*(*SD*)**		***T***	***df***	***p***
		Male (*n* = 936)	**Female (*n* = 1,000)**			
Domains in the Standards of Tertiary Teaching	Domain 1: Content, Knowledge, and Pedagogy	78.46 (14.56)	78.09 (14.00)	0.581	1934	0.562
	Domain 2: Learning Environment	84.35 (13.57)	85.61 (12.45)	–2.131*	1890.33[a]	0.033
	Domain 3: Diversity of Learners	86.35 (13.32)	89.21 (11.69)	–5.008***	1862.80[a]	0.000
	Domain 4: Curriculum and Planning	84.36 (13.71)	84.70 (12.32)	–0.573*	1878.24[a]	0.567
	Domain 5: Assessment and Reporting	81.94 (16.93)	82.07 (16.42)	–0.173	1934	0.863
	Domain 6: Community Linkages and Professional Engagement	84.04 (14.34)	84.85 (13.53)	–1.285	1934	0.199
	Domain 7: Personal Growth and Professional Development	83.41 (16.13)	83.92 (14.51)	–0.740*	1878.76[a]	0.459
	Overall proficiency indicator	**83.27 (12.46)**	**84.06 (11.20)**	**–1.469***	**1878.26[a]**	**0.142**
TPACK Dimensions	TPCK	84.87 (12.95)	85.83 (11.88)	–1.679	1890.65[a]	0.093
	TPK	84.01 (13.00)	85.35 (11.74)	–2.374*	1881.27[a]	0.018
	TCK	73.19 (18.12)	72.06 (17.40)	1.405	1934	0.160
	PCK	81.37 (13.67)	81.90 (12.77)	–0.868	1934	0.385
	TK	82.45 (17.02)	81.29 (18.09)	1.440	1934	0.150
	PK	86.32 (12.19)	88.46 (10.65)	–4.088***	1859.45[a]	0.000
	CK	83.62 (15.64)	82.70 (15.56)	1.294	1934	0.196

Note: *$p \le 0.05$; ***$p \le .01$; [a]Equal variances not assumed

good laboratory practices" like "wearing of proper PPE [personal protective equipment]." Furthermore, to ensure students' safety, she also makes it a point to "orient them [students] where the fire extinguisher, eyewash station, and emergency devices [are]." Similarly, another female teacher declared that she maintains "pre-lab, on-lab, and post-lab" guidelines for students to follow and makes sure that students are aware of why such guidelines exist. A relative case that reflects a female math teacher's organization and attention to details in the classroom, who reported that before the start of any group undertakings, she "show[s] the rubric and explains how each [will be] graded." It is then assumed that Filipino female teachers exhibit better emotional empathy than males (in general), which fosters better rapport with students (Goleman 2011).

For Domain 3 (diversity of learners), the advantage of female teachers lies in underscoring their responsibility in effectively differentiating the classroom and in ensuring that students are in an environment that is responsive to diverse characteristics. Okoroji and Anyanwu (2013) contended that female teachers inherently possess the apt disposition for understanding students. For example, a chemistry teacher reported that during the time of the interview, she has "students who are older than the average" and even "students … who are already older than [her]." This situation prompted her to make them feel that they could approach her (which they eventually did) if they needed anything.

Relatedly, PK involves the teachers' knowledge and understanding of the teaching and learning processes and methods, while TPK describes the interactions between PK and technological tools (Mishra and Koehler 2006). As discussed previously, the higher self-concept of female teachers may be due to their femininity and motherly nature (caring and nurturing), as women are widely thought to be natural caregivers (Martino and Rezai-Rashti 2010). The mentioned case also supports previous reports indicating that female teachers are generally more expressive, supportive, and open towards students (Islahi and Nasreen 2013). Studies also suggest that female teachers tend to share authority in managing the classrooms while keeping the teacher-student relationship intact (Islahi and Nasreen 2013).

Teachers' (in the STEAM Disciplines) Proficiency Difference by School Type

Table 3 compares (in terms of school type: private and government-owned PHE) the teachers' self-concept of the domains of tertiary teaching standards and TPACK dimensions.

Table 3. Domains of tertiary teaching standards and TPACK proficiency comparison between types of schools.

		M(*SD*)				
		Public (*n* = 1,219)	**Private (*n* = 635)**	***T***	***df***	***p***
Domains in the Standards of Tertiary Teaching	Domain 1: Content, Knowledge, and Pedagogy	78.10 (14.35)	78.53 (13.98)	–0.616	1852	0.538
	Domain 2: Learning Environment	84.65 (13.04)	85.74 (12.82)	–1.719	1852	0.086
	Domain 3: Diversity of Learners	87.55 (12.76)	88.25 (12.21)	–1.146	1852	0.252
	Domain 4: Curriculum and Planning	84.38 (13.16)	84.73 (12.72)	–0.552	1852	0.581
	Domain 5: Assessment and Reporting	81.77 (16.34)	82.27 (17.42)	–0.606	1852	0.545
	Domain 6: Community Linkages and Professional Engagement	83.76 (14.44)	85.71 (12.59)	–3.008**	1446.88[a]	0.003
	Domain 7: Personal Growth and Professional Development	83.29 (15.29)	84.07 (15.35)	–1.048	1852	0.295
	Overall proficiency indicator	**83.36 (11.92)**	**84.19 (11.61)**	**–1.435**	**1852**	**0.151**
TPACK Dimensions	TPCK	84.67 (12.70)	86.58 (11.67)	–3.165**	1852	0.002
	TPK	84.29 (12.57)	85.40 (11.90)	–1.825	1852	0.068
	TCK	72.62 (17.49)	72.30 (18.09)	0.377	1852	0.706
	PCK	81.54 (13.28)	81.68 (13.19)	–0.213	1852	0.831
	TK	81.29 (17.55)	82.89 (17.59)	–1.870	1852	0.062
	PK	87.25 (11.72)	87.80 (10.88)	–0.990	1852	0.322
	CK	83.19 (15.84)	83.39 (14.73)	–0.259	1852	0.796

Note: *$p \leq 0.05$; **p=≤ .01; [a]Equal variances not assumed

The comparison (Table 3) shows that private HEIs mark higher than the government-owned HEIs. However, it was noted that there is no significant difference in the teachers' proficiency in terms of the type of school (p = 0.151) despite the perceived score advantage of private HEIs. Specifically, a similar trend was observed in all the domains, except in Domain 6 (community linkages and professional engagement), which reports a significant difference (p = 0.003) in favor of the private HEIs. It was also observed that only one TPACK dimension (TPCK [p = 0.002]) registers a significant difference in terms of school type in favor of private HEIs. In fact, private schools have higher means in the three (TPCK, TPK, and TK) of the four domains with technology (TPCK, TPK, TCK, and TK).

Similarly, their self-professed proficiencies may not be influenced by their school affiliation (whether they are in private or government-owned HEIs) marked by the general non-significance of their differences in their self-professed proficiency level as per their school affiliation. However, our observed statistically noteworthy difference in community linkages (the accomplishment of personal and social development with the community) (Rubio *et al.* 2016) leans on the fact the government expects all HEIs (government-owned and private HEIs) to conduct outreach programs. These are programs that focus on social-development-oriented experiences that will develop service orientation in their respective profession. In the financial perspective, however, the expenditure on extension activities in SUCs (government-owned HEIs) is only about 2% of the total spending in 2012 (Manasan and Revilla 2005). Furthermore, the average tuition fee per unit (AY 2017–2018) for SUCs is Php 216.01 and Php 174.33 in LUCs while in the same academic year, the average tuition fee for private HEI is Php 644.14 (CHED 2018). Assuming that the private HEIs utilized the same percentage, then, their budget will be about thrice the amount of SUCs and LUCs, which makes funding source for extension activities the least of the problem of the private HEIs compared to SUCs and LUCs (Rubio *et al.* 2016). Unlike "SUCs *at* [and] HEIs *na* [that] depending on their budget on the national government [have to depend on the national government for their budget]," it appears that private institutions have more control in the regulation of tuition fees to acquire funds for community extension activities. An administrator from a private HEI revealed that previously, they have "consulted parents… to increase these [tuition and miscellaneous] fees" to purchase laboratory equipment and finance students' extension activities. This is clearly unique to private colleges, unlike in SUCs who "do not have much [resources] to address all these things [institutional expenditures];" hence, they only "prioritize the most important [expenses] then down to the lesser [*sic*]."

This result may hint on institutional affordances sourced from better fund appropriations (for related technology procurement) in private HEIs compared to SUCs and LUCs (CHED 2018; Romero 2018; Rubio *et al.* 2016). Relatively, better faculty to student ratio may also influence the lean on private institutions perceiving quite well in the core of TPACK dimension. Large class size poses a negative correlation with student performance (Koc and Celik 2015), and less quality of instruction by the teacher (Mueller 2013). In fact, SUCs in the National Capital Region report an average faculty to student ratio in AY 2017–18 as 1:26 compared to 1:19 in the private HEIs (CHED 2018). The same trend was observed (Central Visayas [1:29 for SUCs and LUCs compared to 1:19 for private HEIs] and Mindanao region [1:35 for SUCs and LUCs compared to 1:21 in private HEIs]) in the other parts of the archipelago (CHED 2018).

CONCLUSION AND IMPLICATIONS

Teacher quality of teachers in STEAM disciplines defined by their positive self-concept of a tertiary teacher in the STEAM disciplines provides a pragmatic, upbeat, constructive, and optimistic view of teaching and learning of disciplines in the STEAM. However, it is imperative to remark that the result of this study (based on a self-rating instrument) may not represent the actual proficiency of the sampled teachers and may not also reflect the quality of teaching and learning in the STEAM disciplines, as evidenced by the low performance of graduates in the STEAM disciplines in licensure examination and high dropout rates. Nonetheless, the positive view of teachers may motivate more students to the STEAM pipeline and sustain a pool of STEAM professionals as a path towards the improvement of the human capital resource, which the country relies on for its economic growth and well-being. Apparently, education in the STEAM disciplines in this study avows a high level of gender equality confirming reports that the country is the world's 8th best in gender equality and Asia's top (Tomacruz 2018). Though partly, the study implies a culture-based perspective that the Philippine female gender is known to be hospitable and caring, exhibiting better empathy than males. We may attempt to envision full gender equality in all domains and dimensions; however, in the process, we do away with the uniqueness of the Philippine culture.

This country-wide assessment of the teaching proficiency of the teachers in higher and advance learning underscores the use of context-based assessment and evaluation tool (proficiency self-rating tool and classroom observation protocol) grounded on the theories contextualized in the Philippine setting (*i.e.* PSGs, tertiary teaching standards, and TPACK for Filipinos). This assessment practice is believed to provide an overview of the proficiency of these teachers that may cull significant information for policymakers and curriculum designers to craft better policies and curricula for education in the different disciplines of STEAM in the Philippines. The focus is country-based, where the framework and processes of assessment and evaluation that were implemented are based on a global framework (TPACK) and country-wide paradigms (PSGs and tertiary teaching standards). This study may be considered to source valuable data for future undertakings such as a highly structured micro-credentialing system in all professional learning and in the continuing professional development in all fields advocating quality through equity of skills and resources. However, the study only focused on PSGs, tertiary teaching standards, and TPACK paradigms in framing the general proficiency level of PHE teachers in the STEAM disciplines through an online survey with quite a low (a little over half of the intended sample) retrieval rate. Better online survey systems may do the job of increasing retrieval rate for better population representation. Other frameworks and constructs (*i.e.* teaching proficiency in terms of their respective STEAM disciplines) may also influence the assessment of proficiency to ensure a complete package of the quality teacher in the disciplines of STEAM for the country.

Future Directions

A very positive outlook, though, in the teaching and learning may pose threats such as non-acceptance of deficiency in proficiency in certain aspects and domains of teaching and learning. Such may also pose a wrong attribute of teacher quality. This may eventually lead to murky situations for the disciplines under STEAM, deluding teachers to believe that they do not need professional development to improve themselves. Relatively, a number profess low proficiency in specific domains (content knowledge and pedagogy, and assessment and reporting), which may be caused by the teachers' low research engagement and being a non-graduate-degree holder. It may be wise then to confirm such data and correlate the results with the peer-, student-, and supervisor-assessed levels of teachers' proficiency. However, paths as such may call for the larger appropriation of funds for professional development, research and publication capacity building, and research opportunities and grants to improve content knowledge and dissemination as well. These means may also address gender and school affiliation ascendancy if efforts gear to equality in fund appropriation. Furthermore, the government with the education agencies for higher learning may tinker on programs to implicate STEAM education-university-industry partnership and policies on regular proficiency assessment of STEAM teachers as well.

ACKNOWLEDGMENTS

This work was supported by the Philippine Commission on Higher Education and Philippine Normal University. The authors would like to recognize the assistance of team members (Nica Casilla, Ma. Luz Rantael, Ryan Anthony Olalia, and Sienna Joy Galit) in the completion of data collection and manuscript preparation.

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APPENDICES

Table I. Domains and focus proficiencies for tertiary teachers in the different disciplines of STEAM.

Indicator's domains	Focus proficiencies
Domain 1: Content Knowledge, and Pedagogy	Content knowledge in: • The respective disciplines in science, technology, engineering, agri/fisheries, and mathematics (STEAM) • related researches in the respective disciplines under STEAM • related industry and technology (applications, software, hardware, equipment, tools, instruments, *etc.*) • communication in different platforms and media Pedagogy for: • critical thinking, inquiry, and related science process skills • inclusivity in culture and language • research-based instruction
Domain 2: Learning Environment	• Large class management • Safety, precautionary measures in the laboratory • Ethical use of all resources (online and non-web) • Modeling scientific attitudes, traits, and competencies
Domain 3: Diversity of Learners	• Suitability of instruction to diverse learners • Concept of inclusivity in terms of language, gender, and cultural practices and norms • Proper attributes during consultations, advising, and mentoring
Domain 4: Curriculum and Planning	• Adept of knowledge of the prescribed curricula in their respective disciplines • Enactment of the curricula in their respective classroom to achieve spelled our curricular outcomes
Domain 5: Assessment and Reporting	• Coherent assessment and feedback mechanism applicable in their respective disciplines • Ethical use of assessment and assessment outcomes or results • Decision-making using the outcomes or results of the assessment
Domain 6: Community Linkages, and Professional Engagement	• Focus on how teachers utilize their respective disciplines to help inform the community of any activities and research-related programs in their disciplines from which the community may benefit from
Domain 7: Personal Growth and Professional Development	Growth as: • A researcher in the discipline through attendance to conferences, conducting research, and publishing in reputable journals • A pedagogical leader through attendance to seminars, and workshops on pedagogy • A content expert through advance and higher learning

Source: Morales *et al.* (2019)

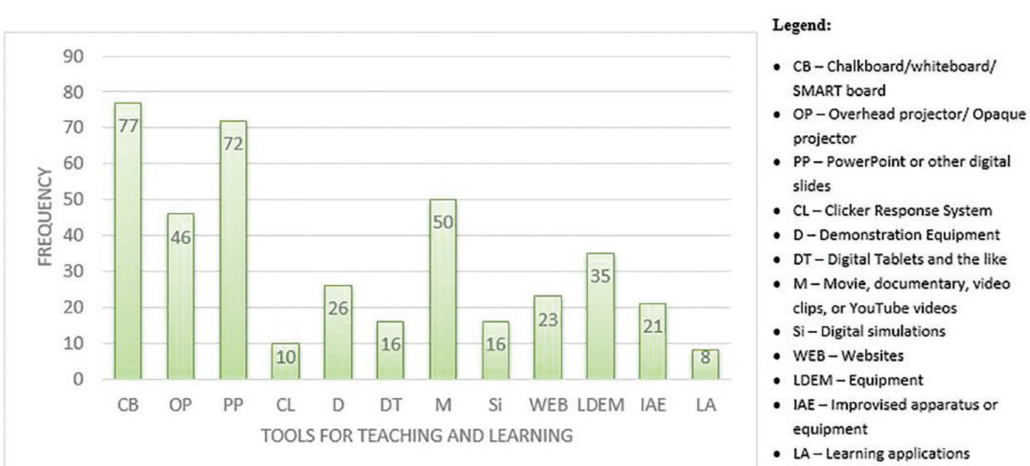

Figure I. Frequency of common tools for teaching and learning used (n = 86).

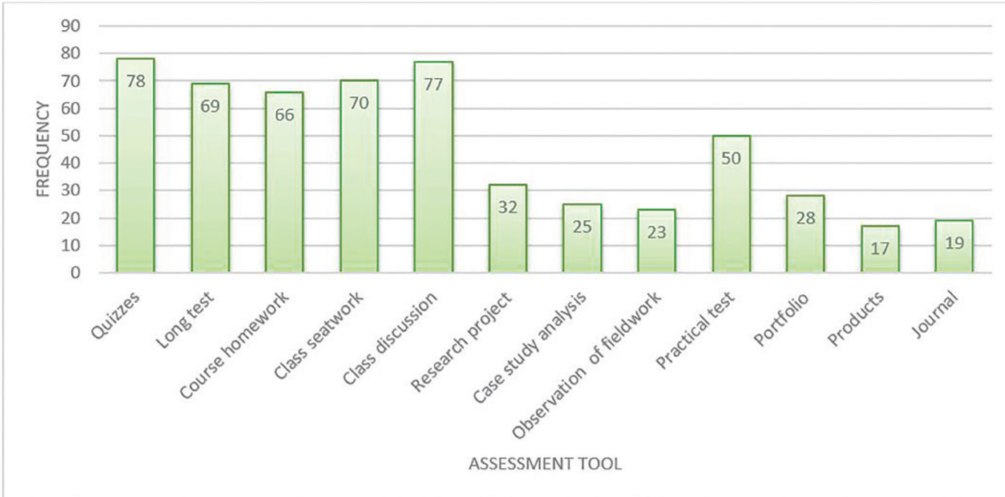

Figure II. Frequency of common assessment tools used (n = 84).

Table II. PRC national passing percentage of STEAM-related disciplines from 2014–2018 (data from https://ched.gov.ph/statistics/).

Discipline	2014 (%)	2015 (%)	2016 (%)	2017 (%)	2018 (%)	Ave.
Science-related						
Chemistry	59.83	53.84	54.86	43.97	45.04	**51.51**
Geology	53.42		50.23	40.49	58.92	**50.77**
Midwifery	48.28	44.82	50.97	44.61	44.56	**46.65**
Nutrition & Dietetics	63.59	64.74		71.86	63.12	**65.83**
Nursing	47.52	51.82	45.85	40.66	41.92	**45.55**
Pharmacy	54.26	60.62	52.66	59.13	63.60	**58.05**
Physical Therapy	55.62	58.95	63.43	61.63	63.40	**60.61**
Medical Technology	79.43	80.55	80.18	81.20	75.89	**79.45**
Respiratory Therapy	61.81	67.95	71.32	61.48	72.92	**67.10**
Occupational Therapy	47.01	62.65	51.06	71.46	67.05	**59.85**
Average	**57.08**	**60.66**	**57.84**	**57.65**	**59.64**	**58.54**
Technology-related						
Radiologic Technology	58.62	43.57	42.83	46.41	47.29	**47.74**
Engineering-related						
Aeronautical Engineering	46.81	60.89	54.14	62.50	51.25	**55.12**
Agricultural Engineering	50.57	40.43	39.60	48.35	56.66	**47.12**
Architecture	58.33	60.98	55.81	56.35	56.58	**57.61**
Chemical Engineering	64.02	55.12	60.27	62.38	61.60	**60.68**
Civil Engineering	47.38	38.42	43.22	44.17	41.91	**43.02**
Electrical Engineering	51.99	60.45	59.70	56.96	61.64	**58.15**
Electronics Engineering	32.86	38.14	39.21	44.87	47.94	**40.60**
Geodetic Engineering	37.37	35.17	41.88	49.73	53.25	**43.48**
Mechanical Engineering	72.85	56.23	65.73	65.72	56.97	**63.50**
Metallurgical Engineering	66.67	65.43	81.69	85.42	72.06	**74.25**
Mining Engineering	84.25	80.84	81.47	88.64	86.50	**84.34**

Table II. Continuation

Naval Architecture & Marine Engineering	54.29	50.65	38.38	43.59	40.31	**45.44**
Sanitary Engineering	64.66	53.72	58.29	56.80	62.06	**59.11**
Average	**56.31**	**53.57**	**55.34**	**58.88**	**57.59**	**56.34**
Agriculture-related						
Agriculture	36.32	31.18	31.01	36.40	38.29	**34.64**
Fisheries Technology		36.62	33.33	34.36	28.24	**33.14**
Environmental Planning	44.67	49.58	53.54	42.42	39.96	**46.03**
Forestry	40.35	47.97	46.16	48.54	59.52	**48.51**
Average	**40.45**	**41.34**	**41.01**	**40.43**	**41.50**	**40.58**
Mathematics-related						
Accountancy	31.42	39.45	38.57	3232.00%	26.73	**33.70**
Overall average						**53.66**

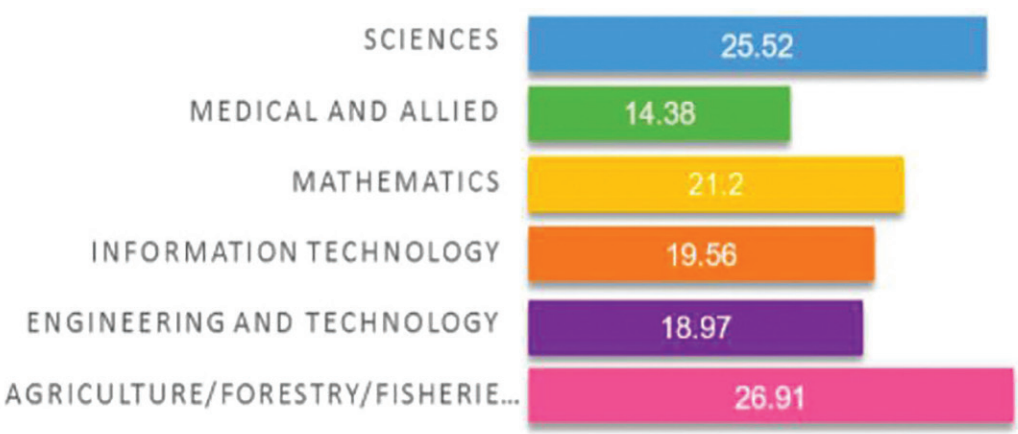

Figure III. Completion rate (%) across STEAM areas calculated for five-year data until SY 2016–2017.