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Assessment practices in Philippine higher STEAM education

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Assessment practices in Philippine higher STEAM education

Abstract

The study explored practices of the sampled higher education Philippine STEAM educators in assessing learners. Data sourced from the database of a state-funded research on Philippine STEAM education using a Classroom Observation Protocol, included 106 STEAM teachers from purposely selected institutions drawn from 14 regions. Systematic data analysis (through data condensation, data display, and drawing and verifying conclusions) revealed that STEAM teachers used both appropriate traditional and authentic assessment tools and strategies with inclusive integration of technology. Furthermore, results showed that STEAM teachers' best assessment practices may be categorised as: 1) assessment for career or industry readiness, 2) mounting assessment system to support instruction, and 3) collective and reflective assessment process. COVID-19 pandemic implications and policy recommendations are also offered, which may enhance assessment practices and suggest a perspective in crafting and recommending national and international standards and guidelines on assessment literacy among higher STEAM educators.

Keywords

assessment, STEAM higher education

Cover Page Footnote

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Introduction

The advent of Industrial Revolution 4.0 (IR4.0) blurs the line that divides the physical and the digital world (Maisiri et al., 2019). This innovation era defined by digital and technological outbursts influences countries to focus on Science, Technology, Engineering, and Mathematics (STEM) field and profession, which is believed to be one of the foundations of knowledge-based economy and society (Savage & Healy, 2019). It dictates the state-of-the-art contour of the workforce where machines compliment men to surface new possibilities and harness potentials for inventions, creations, and novelties (Almeida & Simoes, 2019). Eventually, Science, Technology, Engineering, Agri/Fisheries or Arts, and Mathematics (STEAM) education arose, adding "A" to STEM, for the purpose of better cultivating students' cognitive benefits and to improve employability skills necessary for career and economic progression (Perignat & Katz-Buonincontro, 2019). This new education archetype thrive unique assessment practices, such as assessing student collaboration in engaging to group performances, attitudinal inventories to index students' development of soft skills, or performance-based assessment which is observed as highly motivational in the STEAM disciplines (Herro et al., 2017). Thus, this qualitative study, which is part of a state-funded research project on STEAM education, was conceptualized to provide an empirical body of knowledge on assessing learning in Philippine higher STEAM education.

Background

The Philippines indicates a firm stand on improving the human capital and its science, technology, and innovation sectors, to help bridge the IR4.0 phenomenon (National Economic and Development Authority, 2017). This prompted educational agencies to gear their efforts towards improving the quality of STEAM education, trusting that it will contribute to the economic competence of the country. However, despite the efforts, one in every four young (between 15 to 24 years old) Filipinos are unemployed, with many young people (48.4% of the unemployed population) facing challenges in finding work after they leave schools, due to job skills mismatch (Asian Development Bank, 2018). This implies a potential shortcoming of higher education assessment systems, which might be reflecting deceptive student gains (Fook & Sidhu, 2014). As a consequence, there might be a widening gap between what the students acquire in higher education institutions (HEIs) and skills needed to survive in the continuously advancing technology-permeated workplace.

Salmon (2019) emphasized few trends that stand out in adapting education to meet the demands of IR4.0. He believes that emphasis will be on project-based learning, big data interpretation, and student involvement in curriculum design. As a result, trends in assessment and assessing students will be very different from the conventional forms and platforms (Aziz Hussin, 2018) to adjust to the new learning paradigm. The Philippine education system adheres to the principle of multiple strategies for holistic assessment of student learning and success (Plata, 2018; Rosaroso & Rosaroso, 2015). Yet, although general assessment techniques that come from traditional to authentic kinds of assessment visibly surface on the Philippine education topography, there are clear indicators that the current assessment scheme does not reflect what students need to succeed in their future workplace. Looking at the current assessment practices of STEAM teachers may help shift assessment to gauge skills that are necessary in a complex global environment, which in turn will assist in uplifting the current condition of higher education and human resource.

Literature review

Assessment in higher education

Assessment is the primary propeller of learning that interfaces between what the teacher expects the students to learn, and the evidences that demonstrate students' learning success and achievement (Northcote et al., 2017). In fact, Thomas, Martin, and Pleasants (2011) believe that assessment plays an essential part in providing quality andragogy to adults' lifelong learning process and their partaking in the community and the national economy. In the same manner, Banta and Blaich (2011) describe that assessing learning is a subversive activity, which is beneficial to improve teaching and learning. Furthermore, Maki (2010) explains that assessment is an opportunity for teachers to develop a shared vision of student learning and to collaborate in realizing such goals. Many view assessment as a way to informed decision-making in terms of best practices and instructional delivery (Al-Thani et al., 2014). Additionally, assessment can provide distinct ways to gather evidences for better judgement of student achievement. This fundamental practice, which is central to teaching and learning in higher education, regulates students' progress and can likewise facilitate learning (Chase et al., 2017).

The impact of IR4.0 extends to all sectors, including assessment in higher education. The skills upgrade required in the industry stimulates change to the learning system, which would suggest modifications in the assessment process. In the new education topography, assessment hinges education and research, creating heaps of new knowledge on evidence-based instructional delivery (Hejase & Tabch, 2012). Currently, assessment transitions and transformations are visible to cope with the fast-changing educational landscape. However, conceptualizing and developing assessment tools that can measure cognition as well as skills in this new landscape is a challenge (DiCerbo, 2014), since these changes vehemently push assessment from the traditional form to digital badges and other e-assessment techniques to meet the learning trajectory of the current learners (Chase et al., 2017). The greatest challenges in the perspective of higher education assessment includes providing feedbacks, improving students' decision-making, enhancing active learning and knowledge, and deriving test results which are useful to students (Webb & Gibson, 2015).

Philippine higher STEAM education

Advancement in STEM is believed to propel economic progress and advancement (English, 2016). On this note, the Department of Education (DepEd) of the Philippines included STEM as one of the tracks of the K to 12 senior high school curricula, which prepares students to take a higher education degree in any STEM related disciplines. However, the Philippine Commission on Higher Education (CHED) expanded the DepEd's vision for STEM to a clustering of disciplines as STEAM, where A represents agri-fisheries courses. This choice is rooted from the fact that agriculture plays a significant role in the Philippine economy, involving about 24.3% of Filipino workers in 2018 according to the World Bank collection of development indicators.

The CHED recognizes that the Philippines may benefit from STEAM professionals for its human capital. In fact, the government positioned STEAM disciplines at the foreground to improve the present global metrics of the country according to international standards (National Economic and Development Authority, 2017). Unfortunately, despite attempts to proliferate STEAM education in the Philippines, only 38.5% out of the 3,589,484 collegiate enrolment in 2019 chose disciplines under STEAM, with merely 21.9% completion rate (Commission on Higher Education, 2019).

In an effort to contribute to uplifting STEAM education, we conceived this qualitative research to understand how learning is assessed in Philippine higher STEAM education. This study examined various data gleaned on different STEAM constructs from 14 regions. The purpose is to: (1) determine the current assessment practices of higher education STEAM teachers; (2) benchmark teachers' best practices in assessing STEAM students; and (3) suggest policies and programs that could alleviate assessment in higher STEAM education.

Methods

To attain our objectives, we sought qualitative data from a state-funded research project in Philippine STEAM education (Morales et al., 2018). The said project, which aims to craft an emerging Technological Pedagogical Assessment Content Knowledge (TPACK) Model and provide inputs to policies for Philippine STEAM education, has a vast database of quantitative and qualitative data that we were permitted to access and use for this research. The database hosts responses from 103 randomly selected HEIs (out of 2,299), which includes 46 public and 57 private institutions of higher learning all over the country. Complete enumeration (n = 1,940) of STEAM teachers in the identified institutions was done in the research project. From this initial sample, 106 teachers (see Table 1 for the distribution per region) were selected based on recommendations for classroom observations and comprehensive interviews.

Table 1
Distribution of STEAM teacher respondents per region

Region	Number of Schools	Number of STEAM Teachers
I	2	5
II	1	4
III	3	15
IV	3	16
V	3	9
VI	2	10
VII	2	4
VIII	1	5
IX	1	5
X	2	4
XI	2	7
XII	2	8
National Capital Region (NCR)	5	10
Cordillera Administrative Region (CAR)	1	4
Total	31	106

The data from the 106 STEAM teachers, which were gathered through: 1) classroom observation notes, 2) interview protocol, and 3) assessment checklist, were used to address the objectives of this paper. The first two instruments include open-ended questions that intend to collect observations, information, explanation, and exploration of meanings behind the practices of STEAM teachers; while the third is a checklist of the various techniques that STEAM teachers utilize to assess the performance of the students. The said data were collected by trained field researchers, who were deployed in the various HEIs to conduct observations, interviews, and collect other pertinent information. These field researchers were also tasked to transcribe and organize the data collected because they were more familiar to the data and to ensure that no details were missed. The organized

information and transcriptions were uploaded in the database of project, where we retrieved the necessary materials needed for analysis.

We used MAXQDA 10 to organize the transcriptions and to facilitate analysis. The technique proposed by Miles, Huberman and Saldaña (2014) were employed to analyze and triangulate the qualitative data. This technique involves three concurrent processes: 1) data condensation, 2) data display, and 3) drawing and verifying conclusions. Iterative procedure was practiced in this study since qualitative data analysis is nonlinear in nature (Lochmiller & Lester, 2017). To be exact, data analysis for this study involved returning and analysing the raw data, memos, codes and figures several times to arrive at the most precise themes.

Additionally, as qualitative analysis is an extremely interpretative research and may be subject to validity and reliability concerns (Drost, 2011), we conducted a two-day workshop to evaluate and gain additional insights about the results of our analysis. Furthermore, we presented the results in a capability building program and national forum, which is part of the research project mentioned and was attended by STEAM teachers from sampled HEIs, to ensure the soundness and integrity of the conclusions derived from the data. These themes are presented in narrative form in the next section.

Results

In this section, we present the identified assessment practices of Higher Education STEAM teachers in the Philippines. Correspondingly, the best practices were derived based on how curriculum, instruction, and assessment were able to reinforce each other according to the standards emphasized by STEAM Education. Although the common practices were identified from the sampled HEIs, the best practices highlighted in this study may not exactly represent the most commonly utilized assessment practices; but rather, they signify how assessment could be further enhanced for a more relevant STEAM education for the country.

Assessment for career/industry readiness and development of essential skills

The practices included in this category represent the long-term goals and curricular objectives being put forward by STEAM education in the Philippines, which highly affects the assessment practices of teachers. Although traditional forms of assessment still prevail as the most widely used, several STEAM educator-participants are fervently mindful of the following assessment practices: (a) inclusion of real-life application problems specific to various disciplines; (b) involvement of (other) experts and stakeholders in the assessment process; (c) selection of appropriate assessment based on the competencies and expected outcomes; and (d) assignment of roles to students.

Inclusion of real-life application problems specific to various disciplines

In general, the teachers from the sampled HEIs hold on to a unified and overarching aim for their STEAM learners to become productive citizens, '*If students will study STEAM courses, there will be a big improvement in our country, in our society*.' The differences and varied interests and abilities of every student are taken into consideration, and subsequently delivered and assessed via more experiential approaches. A faculty from Region VI stated,

> *I always try to find out the interest of my students… I want them to share their actual experiences in life, reflected to the subject matter itself. There is always a difference in the actual experience and the knowledge that you gain from the book and other sources.*

Relatedly, the inclusion of questions that provoke higher order thinking skills (HOTS) and critical thinking were considered as best practices. The following statements were uttered by some participants: '*we are all encouraged as faculty members to include higher order thinking skills* [questions during assessment]'; '*I keep on giving that kind of items* [critical thinking items] *so that they will get used to it… and will most likely develop critical thinking.*'

Involvement of (other) experts and stakeholders in the assessment process

Enablers of STEAM Assessment, institutional affordances and sustainability, were identified as important variables in the assessment practice of STEAM education in the Philippines. HEIs collaborate with industry and community partners to provide relevant experiences (in the form of internship) that will prepare students to be competent in their respective fields. This activity engages student-interns and permits them to interact with different individuals and systems providing them the opportunity to contextualize learning, '*they experience* [using laboratory equipment] *during their practicum, so they know how to operate those* [laboratory] *instruments.*' Internship is included in the curriculum of all STEAM disciplines in the Philippines, and is usually taken as a credit-bearing course supervised by a teacher, where a coordinating member of the partner industry also evaluates the performance of the student-interns, '*we invite industry partners to collaborate and check* [students' performance]*… we have an evaluation form for the supervisors to evaluate our OJTs* [On the Job Trainees].'

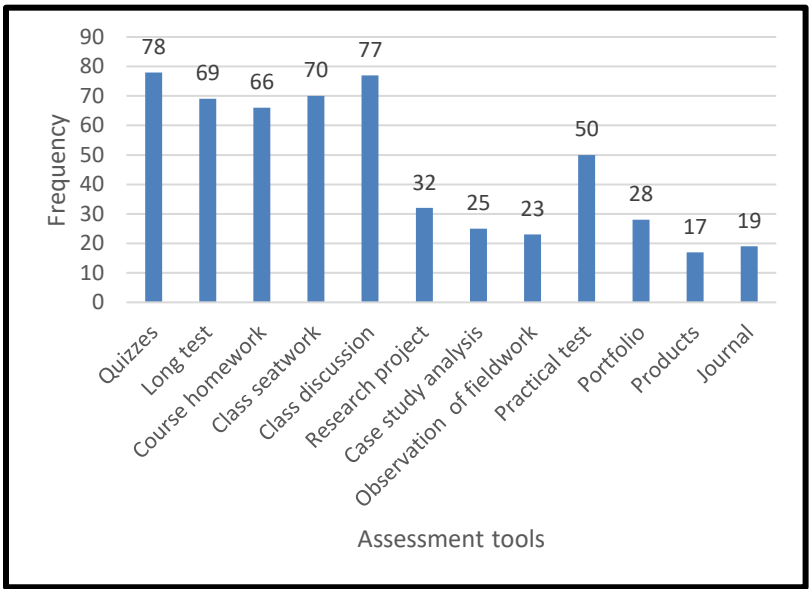
Exceptional instances where the industry partner contributes by sharing assessment tools to faculty members were also observed. In particular, a city college in Region III has an association with a multinational IT (Information Technology) and business process outsourcing company that supplies them with industry-related ICT (Information and Communication Technology) test questions, '*it is a partnership with* [Name of partner industry]. *They provide us with ICT questions that we can use in our classes.*' Industry partners are also invited to update students about new technologies and systems used in the field and the day-by-day scenario in the workplace, aiming to give STEAM students better grounding and employability.

> *We invite our industry partners to update us about applications or software that they use, so when our students graduate, they know the demand and will have higher employability rate.*

Selection of appropriate assessment based on the competencies and expected outcomes

Assessment practices of the participants reveal implications to instructional objectives or purposes, also considering short-, medium-, and long-term goals. The assessment checklist reveals that most of the sampled teachers tend to administer traditional forms of assessment, while only few uses the more authentic types of assessment (see Figure 1). Moreover, a participant admitted that, '*it is our* [their] *routine to give questions that are related to the topics or module for the board exam.*' Aside from the format, teachers also administer test items that have the same level of difficulty, '*like board exam question level of difficulties*,' because their '*goal in teaching is for our* [their] *students to pass the board exam.*'

Figure 1
Bar chart of assessment tool utilization (n = 84)



Although STEAM teachers admit that they usually tailor-fit the assessment to mimic licensing examinations, observation reveals that some of them likewise push boundaries for deeper and substantive learning to provoke innovation among STEAM learners. As mentioned, we observed teachers who know the importance and ask HOTS and critical thinking questions during assessment. They also apply authentic assessment through the application of real-life scenarios and engagement in practicum activities. It was also evident that STEAM teachers assign roles that challenge students to be involved and active participants. This scenario is discussed in detail in the next section.

Assignment of roles to students

Role-playing and simulations were detected among the participants, where STEAM learners were evaluated while assuming various roles and are interacting in real-life setting. For instance, a midwifery professor emphasized that they initially teach and assess their students how to deliver a baby through simulation, '*for birthing, we have an OR* [Operating Room]*... we have beds for simulation purposes.*' Similarly, another participant cited the importance of simulation in ensuring that pre-med students understood the proper use and safety precautions in administering injections, '*we have simulations on the proper administration of injection… and the correct usage of needles.*' Additional example is provided in Figure 2 that displays a practical exam in cardiopulmonary resuscitation (CPR) of observed pre-med students. These types of assessment modality require students to perform specific tasks in which they could demonstrate learned skills, capabilities, and know-how in an actual field setting.

Figure 2
Observed practical exam of pre-med students

On a similar note, one teacher participant stressed that he gave activities (in a professional ethics course) that would allow students to empathize in different roles in the society and challenge them to respond or act accordingly.

> *I gave students real life questions. I throw them questions about our society. For example, in our professional ethics* [class], *I give them case studies where they have to react or tell what they will do in that situation.*

A teacher mentioned that their institution provides simulation materials, '*we have simulation materials if needed, everything is provided* [by the institution],' thus the students need not purchase them anymore.

Mounting assessment systems to support instruction

Several time-honoured assessment practices are still being done in HEIs and are being utilised with authentic assessment tasks, such as the following: 1) ensuring balanced distribution of items in terms of content, difficulty, and assessment tools; 2) remediation for students having difficulties and misconceptions; 3) inclusion of questions that provoke HOTS and critical thinking; 4) repetition of items/activities for mastery of skills; 5) orientation of learners about expectations for the assessment and how they will be graded; 6) proper monitoring of the assessment implementation; 7) use of appropriate grouping strategies; and 8) utilization of rubrics.

It was observed that teachers involve students in a series of learning conditions that are geared to equip knowledge and skills to achieve learning goals and reach set standards, which are usually the basis of assessment.

> *And then for the competencies, I check if an activity requires a difficult output… then for the next activity, I try to find new competencies that I can develop*.

Teachers listen, observe, and examine students' progress and work during each lesson to see how students are performing, '*you can say if your students are not learning or did not understand.*' They investigate, inquire, refine and seek for indications to understand where students are, (*you can determine what their difficulties are*), see what the gaps are, and motivate and remediate students to succeed in the process (*remedy that* [difficult] *part… and later you will know if they improved or if what you did actually helped the student*). Furthermore, evaluation empowers the teachers to adjust and adapt their practices, instruction, and assessment to meet the learners' needs (*I will have an idea if I am too fast or the coverage is too broad; if I need to remove, add or enhance the idea in the topic*).

Technology-enhanced assessments

Our investigations revealed varying practices among STEAM teachers in terms of technology supported assessment, which is greatly affected by the support and resources of the HEIs. Some schools have a technology integrated system (*we have this e-learning management system*) that can support and deliver assessments beyond contact hours and off-campus. Some teachers also explore the use of other open access websites and social media (*There are faculty members who utilize websites apart from our learning management system*; *we also use means like social media especially Facebook and other learning management system like Edmodo*). Additionally, it was observed that some universities utilize advanced technology to ensure quality of submission (*we have TurnItIn*) and to guarantee ethical practices in the dissemination and reporting of grades (*they* [faculty members] *upload the grades* [in a secured school portal] *to ensure confidentiality*).

Collaborative and reflective assessment process

Collaboration and reflection are two procedures teachers use to innovate their practice (Murray, 2015; Owen & Davis, 2011). Even if finding the time to do so can be quite challenging, these are present in the practices and are observed in assessing learning in Philippine STEAM education. Collaboration and reflection exist in the process not just among STEAM teachers but also with administrators, students, industry partners, and others, ensuring the participation of all stakeholders in the assessment process. A best practice for instance is in the development of major exams, where teachers teaching the same subject contribute test items and examine together the difficulty of the exam, '*In the departmental final exam, all teachers teaching the subject have to give their contribution and help determine or assess the difficulty of exam.*' This process also involves the leadership of the department head and subject coordinators (*teachers' exams are reviewed by program chairs*). Moreover, this strategy allows teachers without background in education to learn concepts of the assessment processes and the principles of the Bloom's Taxonomy from peers (*we encourage teachers to create questions using the Bloom's taxonomy… not all teachers are aware of that... not everybody has a background in education.*).

A noteworthy practice of collaboration and reflection is when teachers deliberate grades or actions that will be given to students (*we always have an actual deliberation every term… there is a*

committee that facilitates the deliberation of grades, rewards, or punishments that will be given to students). Teachers also reflect on the results of the assessment and uses findings to '*determine areas that students' find difficult*,' '*decide whether* [they] *need to reteach a little before proceeding to the next*,' and in the process improve their assessment and classroom practices. Teachers also train students to be reflective practitioners by encouraging them to reflect on the results of their own assessment (*whenever we have quizzes or assessments, I provide feedback so that they could reflect and find ways to improve*).

Discussion

Jobs are increasingly relying on technology and unified STEM skills, which means that it is essential for students to develop scientific, mathematical, and imaginative dimensions. For this purpose, STEAM education was crafted to distinctively cater students STEM learning and creativity, and to enhance problem-solving skills in real-world setting (Perignat & Katz-Buonincontro, 2019). It emphasizes the significance of incorporating education domain generating skills such as perspective-taking, problem-solving and creative skills, knowledge transmission through disciplines, and/or inspiring students to experience and explore new ways of knowing. Successful STEAM education can empower the human capital for IR4.0, which requires the qualities and attributes of STEAM-skilled professionals (National Economic and Development Authority, 2017).

The onset of IR4.0 serves as a game-changer as teachers assess skills and competencies that are challenging (or not conventionally common) to measure, which takes different forms depending on the fields under STEAM education. Assessment for career readiness legitimizes and even strengthens several pedagogical strategies such as modelling, immersion and apprenticeship, and authentic learning as practiced by teachers in higher STEAM education. This is to prepare learners for various industries, some of which requires heavy procedural fluency, while others necessitate strategical reasoning and deep cognitive abstractions (Maisiri et al., 2019). Thus, the focus of assessment is not only to measure intellectual/academic accomplishment, but also to prepare students in the work environment that awaits them when they graduate. Developing higher order and critical thinking mindsets motivate students to apply skills which challenges them to evaluate, deduce, and apply relevant information to come up with innovative solutions and judgements, which are necessary to be a contributing member of the workforce (Maisiri et al., 2019).

The role of industry partners

Orienting assessment towards aimed career/industry allows teachers to pay attention to what is essential in STEAM education (Perignat & Katz-Buonincontro, 2019). Students would also be engaged, actively involved, and provided with individualized attention. It would also demand appropriate management architecture, support, manpower, curriculum structure and implementation, and policies from HEIs offering STEAM education. In fact, it highlights the enabling factor of educators who are going to deliver the instruction – reiterating that best practices are pushed when the curriculum, instruction, and assessment are constructively aligned and reinforce each other (Dawson et al., 2013).

Evidently, building stronger relationships with industry partners can help improve learning outcomes and address the poor employability of graduates, since education will be tailored according to the skills needed in the workplace (Tiwari & Anjum, 2014). In fact, these partners provides opportunity for role-playing and simulations; which triggers experiential learning (Russell & Shepherd, 2010). The experience provided by industry partners can gauge students' mechanisms in handling different scenarios that may occur in their prospective fields, and confidence in

overcoming difficult situations and managing bizarre cases. These practices also provide opportunities for students to engage in problem-solving that entails them to find creative and noble ways to do things as knowledge is contextualized and questions are addressed in a more meaningful fashion. Indeed, a stronger experiential learning focus could facilitate the transformation of fact-based knowledge about careers/industries into the actual skilled job performances (Helyer, 2015). Role-playing and simulation help students examine problems, assess decisions and actions, and connect lessons learned in the classroom to real-life situations (Russell & Shepherd, 2010); which also require support from the institution.

However, although the industry partners clearly play a major role in assessing STEAM students, especially during practicum, at present, there is no clear parameters that maps partnership between HEIs and industry cohorts. Hence, we suggest that CHED crafts a memorandum order that mandates all HEIs to develop a standardize guidelines that could properly direct industry partners in assessing STEAM students and establish their role in STEAM education.

Technology and assessment process

Technology-enhanced assessment is critical in engendering the different learning ecosystems in the face of IR4.0. As challenging as it could be, based on the affordances and constraints in each of the Philippine HEI, data from the investigation revealed how it could also support student learning. Technology-enhanced assessment has the power to provide immediate feedback on students' learning progress that would facilitate flexibility on the part of the teacher (and students) in terms of what the students are learning or where they are having difficulty at, and make necessary decisions on how to proceed with the courses or programs (Northcote et al., 2017; Schmauss, 2015). It can also increase the productivity of teachers by automating mechanical tasks like computation of grades. Capitalizing on the use of technology and utilizing it to create assessment systems could facilitate the alignment of assessment with Philippine Higher Education PSGs (Policies, Standards, and Guidelines) to enhance curriculum and instruction.

Evidently, our investigations revealed a spectrum of relevant assessment practices among STEAM teachers. But it is important to note that higher education STEAM teachers tend to keen on more traditional assessment forms than more authentic ones (Figure 1), probably because of the lack of appropriate training in implementing other types of assessment, and the scarcity of resources and available technology. In this regard, HEIs should allocate enough budget that could promote, assist, and sustain STEAM teachers' access to updated and pertinent resources, technology, training, and information that could potentially improve assessment literacy, practices, and efficiency. On a similar note, another observable reason why teachers favor more traditional forms of assessment is their inclination to pattern assessments in the licensure examinations that students will take when they graduate, which is paper-and-pencil in nature. Thus, the Professional Regulation Commission (PRC) of the Philippines and other licencing body should regularly update the landscape of the assessment process they implement to match the demands of the changes in education and in the industry, by developing and implementing a research-based quality standards framework in professional assessment.

The implementation of STEAM Education in HEIs in the Philippines is still in its nascent stages. Therefore, the transition from traditional to a more STEAM-oriented assessment will draw from the time-tested assessment practices that have been existent and pushing for a broader set of tools that would allow documentation of students' learning outcomes and mechanisms of knowing what students know. Analysis of students' growth on these assessments permits teachers and students to reflect on what students have learned, to build students' strengths, and to fill in any breach on

students' knowledge and skills (McKevitt, 2016). This scheme guarantees an inclusive and reflective method of decision making among faculty members, and consideration of relevant empirical information and moral bases for decisions. Thus, to better promote collaborative and reflective assessment practices, it is suggested that HEIs encourage and support teachers' communities of practice in developing and sharing innovative assessment practices, through monetary and promotional incentives.

Lastly, although we expect variations in the assessment practices of the STEAM teachers we observed, there should be harmony in STEAM assessment among HEIs in the country to ensure that graduates meet the standards necessary to join the future workforce. At present, there is no assessment indicators for higher STEAM education that serves as blueprint for STEAM teachers in conducting assessment, which explains the broad diversity in practice. Accordingly, the CHED should create a governing body that at the national level, will define the vision, strategies, and plans that would standardize, regulate, and monitor STEAM assessment practices.

Consequences to COVID-19 crisis

The unforeseen spread of COVID-19 compelled educational institutions to deliver classes in a flexible modality and explore alternatives that could assist instruction in a non-face-to-face modality (Scull et al., 2020). This abrupt change necessitates major shifts in assessment culture and adds another dimension in the assessment practices of teachers in higher STEAM education. Universities and higher education alike face massive challenges concerning how to operate efficiently in the so called 'new normal,' including assessing learning (Deepika, 2020). Furthermore, the immediate demand for flexible learning, directed teachers to hurriedly alter their practices, accountabilities, and assessment routines. Educational sectors in many parts of the world strategize on how account teaching and learning through meaningful assessment practices during the pandemic (Scull et al., 2020). Consequently, we went back to our findings and highlighted STEAM practices in the area of assessment that stakeholders can consider to ensure the continuity of education and quality learning transfer amidst COVID19.

Our findings indicate that assessment in the Philippine higher STEAM education is highly tailored for a set-up with physical meetings and does not account for a flexible learning modality. The delivery of education in the new normal assumes a certain level of student independence (Deepika, 2020), which many STEAM teachers did not originally account for. Moreover, the data that we have indicates that many STEAM teachers lack the mechanisms and preparation to conduct evaluation, provide feedback, and offer formative guidance to students in a flexible learning scenario. These rapid changes require assessment practices of teachers to presume that they have already established particular competencies and digital technology know-how. Lack thereof might lead to failure in attaining required learning standards and struggle in developing new knowledge and skills through self-paced learning among students (Abdullah et al., 2020).

As such, we highly encourage the CHED and HEIs to provide appropriate training and support to enable STEAM teachers to function in various learning environments, especially in a flexible one. Furthermore, HEIs should invest in technologies and infrastructures that could support learning and the implementation of assessment, even when physical meetings are not possible, and ensure quality education delivery in different environments. Additionally, HEIs should take into account that upon return to the 'old normal,' teachers may also have difficulty assessing students' learning levels to identify whether students met the standards, if there are any learning losses or gaps resulting from HEI closure, and essential corrective actions undertake (Abdullah et al., 2020). Such assessments may be crutial in apprising learning process, how to proceed with instruction, and boosting the

learning of those who lag behind because of the crisis (Turner et al., 2020). This necessitates HEIs to prepare in advance and depending on the strategies to flexible learning and school reopening procedure, may need to conceptualize and utilize modifications on assessment structures.

Conclusion and recommendations

This study explored and identified the common and best assessment practices employed by STEAM teachers from different HEIs in the Philippines. More particularly, these assessment practices, utilizing both traditional and authentic tools and strategies, were categorized as readiness for career or industry, systems to support instruction, and collaborative and reflective processes. The results highlight the effective use of perennial and established assessment practices in monitoring and evaluating students' learning and academic progress; describes how STEAM teachers collaborate, reflect and utilize real-life situations, stakeholders' participation, role-playing, simulations, and technology-enhanced tools and techniques for the different purposes of assessment; and emphasize STEAM teachers' capability in utilizing assessment information, like students' scores, misconceptions, and difficulties, to address academic challenges and to enhance pedagogical practices. However, our findings also hinted that STEAM teachers do not have the preparation required to incorporate assessment in a flexible learning environment brought by the COVID19 pandemic.

This study showcases 'best practices,' which STEAM educators can use as benchmark to nurture quality assessment delivery and assessment literacy. Furthermore, based on our findings, we suggested several recommendations that could potentially improve and standardize assessment in STEAM education, assist in assuring that assessment practices measure skills that students need in the technology-driven industry, and facilitate quality STEAM education despite an international crisis like COVID19. This mechanisms and programs could also offer a perspective in crafting and recommending national and international policies on assessment literacy and standards among HEIs' STEAM educators.

The findings of this study may inspire the STEAM education community to develop notions regarding best practices in the assessment process that will successfully harmonize the roles of each stakeholders; and may serve as basis for future research studies aiming to motivate teachers to innovate the way assessment is done. This will provide avenues in measuring and developing innovative assessment processes and practices among educators in order to realize the outcomes of STEAM disciplines in terms of the new teaching standards. Lastly, this paper could serve as basis for other countries, particularly those who have similar circumstances with the Philippines, for exploring assessment practices in higher STEAM education and for crafting guidelines and policies that could help ensure that assessment gauges quality education that meets the demand of IR4.0.

Limitations and future research

The results of this study reflect assessment practices and highlights best practices in Philippine higher STEAM education. Moreover, we offer policy and program suggestions for the improvement of the assessment practices that we have identified. Nevertheless, these results must be interpreted with care and some limitations should pondered. For instance, the practices were documented based on highly qualitative data, and thus, does not mirror quantity or frequency of use. Furthermore, the associations between the factors affecting assessment that we have discussed were mainly supported by our observations and previous studies, which are currently not supported with statistical analysis. Hence, we suggest that researches should be done to quantitatively confirm our findings. Additionally, our analysis echoed practices that takes STEAM as a clustering of disciplines and does

not indicate features specific to individual STEAM areas. Investigating the unique assessment practices in each STEAM discipline might further enrich our results. Lastly, future research may also consider looking at the entire higher education assessment practices, to give a better view of assessment and determine how it can be used to prepare the future workforce in IR4.0.

References

Abdullah, M., Husin, N. A., & Haider, A. (2020). Development of post-pandemic COVID19 higher education resilience framework in Malaysia. *Archives of Business Research*. https://doi.org/10.14738/abr.85.8321

Al-Thani, S. J., Abdelmoneim, A., Daoud, K., Cherif, A., & Moukarzel, D. (2014). Developing, implementing and improving learning outcomes assessment in Qatar's public higher education. *Near and Middle Eastern Journal of Research in Education*, *2014*(3), 1–11. https://doi.org/10.5339/nmejre.2014.3

Almeida, F., & Simoes, J. (2019). The role of serious games, gamification and industry 4.0 tools in the education 4.0 paradigm. *Contemporary Educational Technology*, *10*(2), 120–136. https://doi.org/10.30935/cet.554469

Asian Development Bank. (2018). *Reducing Youth Not in Employment, Education, or Training through JobStart Philippines* (Issue 87). https://www.adb.org/publications/reducing-youth-not-in-employment-education-philippines

Aziz Hussin, A. (2018). Education 4.0 Made simple: Ideas for teaching. *International Journal of Education and Literacy Studies*, *6*(3), 92–98. https://doi.org/10.7575/aiac.ijels.v.6n.3p.92

Banta, T. W., & Blaich, C. (2011). Closing the assessment loop. *Change*, *43*(1), 22–27. https://doi.org/10.1080/00091383.2011.538642

Chase, A. M., Ross, B., & Robbie, D. (2017). Improving digital assessment practice: A case study of a cross-institutional initiative. *Journal of University Teaching and Learning Practice*, *14*(2), 1–18.

Commission on Higher Education. (2019). *2019 Higher Education Facts and Figures*. https://ched.gov.ph/2019-higher- education-facts-and-figures/

Dawson, P., Bearman, M., Boud, D. J., Hall, M., Molloy, E. K., Bennett, S., & Joughin, G. (2013). Assessment might dictate the curriculum, but what dictates assessment? *Teaching and Learning Inquiry*, *1*(1), 107–111. https://doi.org/10.20343/teachlearninqu.1.1.107

Deepika, N. (2020). The impact of online learning during COVID-19: students' and teachers' perspective. *The International Journal of Indian Psychology*.

DiCerbo, K. (2014). Assessment and teaching of 21st century skills. *Assessment in Education: Principles, Policy & Practice*. https://doi.org/10.1080/0969594x.2014.931836

Drost, E. A. (2011). Validity and reliability in social science research. *Education Research and Perspectives*, *38*(1), 105–123.

English, L. D. (2016). STEM education K-12: Perspectives on integration. In *International Journal of STEM Education*. https://doi.org/10.1186/s40594-016-0036-1

Fook, C. Y., & Sidhu, G. K. (2014). Assessment practices in higher education in United States. *Procedia - Social and Behavioral Sciences*, *123*, 299–306. https://doi.org/10.1016/j.sbspro.2014.01.1427

Hejase, H. J., & Tabch, H. (2012). Ethics education: An assessment case of the American University of science and technology – Lebanon. *International Journal of Islamic and Middle Eastern Finance and Management*, *5*(2), 116–133. https://doi.org/10.1108/17538391211233416

Helyer, R. (2015). Learning through reflection: the critical role of reflection in work-based learning (WBL). *Journal of Work-Applied Management*, *7*(1), 2205–2062. https://doi.org/10.1108/jwam-10-2015-003

Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-Measure: developing an assessment for student collaboration in STEAM activities. *International Journal of STEM Education*, *4*(26), 1–12. https://doi.org/10.1186/s40594-017-0094-z

Lochmiller, C. R., & Lester, J. N. (2017). *An introduction to educational research: Connecting methods to practice*. SAGE Publications, Inc.

Maisiri, W., Darwish, H., & van Dyk, L. (2019). An investigation of Industry 4.0 skills requirements. *South African Journal of Industrial Engineering*, *30*(3), 90–105.

Maki, P. L. (2010). *Assessing for Learning: Building a Sustainable Commitment across the Institution* (2nd ed.). Stylus Publishing, LLC.

McKevitt, C. T. (2016). Engaging students with self-assessment and tutor feedback to improve performance and support assessment capacity. *Journal of University Teaching and Learning Practice*, *13*(1).

Miles, M. B., Huberman, M., & Saldaña, J. (2014). Qualitative Data Analysis A Methods Sourcebook 3rd edition. In *SAGE Publications*. SAGE Publications, Inc. https://doi.org/10.1016/S0301-4622(98)00172-0

Morales, M. P. E., Abulon, E. R., Anito, J. C. J., Avilla, R. A., Palisoc, C. P., Elipane, L. E., & Casilla, N. A. (2018). *TPACK in Philippine STEAM Education*. Philippine Normal University.

Murray, E. (2015). Improving teaching through collaborative reflective teaching cycles. *Investigations in Mathematics Learning*, *7*(3), 23–29. https://doi.org/10.1080/24727466.2015.11790343

National Economic and Development Authority. (2017). Philippine Development Plan 2017-2022. In *National Economic and Development Authority*. https://doi.org/10 July 2012

Northcote, M., Morton, L., Williams, A., Kilgour, P., & Hattingh, S. S. (2017). Transforming assessment feedback design: Students' responses to adaptively-released assessment feedback (ARAF) strategies. *Journal of Assessment and Institutional Effectiveness*, *7*(1–2), 41–68. https://doi.org/10.5325/jasseinsteffe.7.1-2.0041

Owen, S., & Davis, G. (2011). Catering for student diversity: Building academic skills in graduate attributes learning and assessment opportunities through collaborative work. *Journal of University Teaching & Learning Practice*, *8*(2), 1–11.

Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, *31*, 31–43. https://doi.org/10.1016/j.tsc.2018.10.002

Plata, S. (2018). Minding the Gap: Exploring assessment education in CHED's teacher preparation program in the context of PPST and DepEd's assessment reform. *DLSU Research Congress 2018*. https://www.dlsu.edu.ph/wp-content/uploads/pdf/conferences/research-congress-proceedings/2018/lli-01.pdf

Rosaroso, R. C., & Rosaroso, N. A. (2015). Performance-based Assessment in Selected Higher Education Institutions in Cebu City , Philippines. *Asia Pacific Journal of Multidisciplinary Research*, *3*(4), 72–77.

Russell, C., & Shepherd, J. (2010). Online role-play environments for higher education. *British Journal of Educational Technology*, *41*(6), 992–1002. https://doi.org/10.1111/j.1467-8535.2009.01048.x

Salmon, G. (2019). May the fourth be with you: Creating Education 4.0. *Journal of Learning for Development (JL4D)*, *6*(1), 95–115. https://jl4d.org/index.php/ejl4d/article/view/352

Savage, J., & Healy, J. (2019). Creative teaching design in STEM: Using graduate learning outcomes to distribute students' existing knowledge in first-year biology practical work groups. *Journal of University Teaching and Learning Practice*, *16*(3), 1–13.

Schmauss, S. (2015). Sustainability assessment tools in higher education institutions: Mapping Trends and Good Practices Around the World. *Journal of Cleaner Production*, *106*, 332. https://doi.org/10.1016/j.jclepro.2014.12.049

Scull, J., Phillips, M., Sharma, U., & Garnier, K. (2020). Innovations in teacher education at the time of COVID19: an Australian perspective. *Journal of Education for Teaching*. https://doi.org/10.1080/02607476.2020.1802701

Thomas, G., Martin, D., & Pleasants, K. (2011). Using self- and peer-assessment to enhance students' future-learning in higher education . *Journal of University Teaching Learning Practice*, *8*(1), 1–17.

Tiwari, R., & Anjum, B. (2014). Role of higher education institutions and industry academia collaboration for skill enhancement. *Journal of Business Management & Social Sciences Research (JBM&SSR)*, *3*(11), 27–34.

Turner, K. L., Hughes, M., & Presland, K. (2020). Learning loss, a potential challenge for transition to undergraduate study following COVID19 school disruption. *Journal of Chemical Education*. https://doi.org/10.1021/acs.jchemed.0c00705

Webb, M., & Gibson, D. (2015). Technology enhanced assessment in complex collaborative settings. *Education and Information Technologies*. https://doi.org/10.1007/s10639-015-9413-5