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TPACK IN PHILIPPINE STEAM EDUCATION

THE PEDAGOGICAL MODEL

CHAPTER 2

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ABSTRACT

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Marie Paz E. Morales, Jovito C. Anito Jr., Caesar P. Palisoc

A model of Philippine STEAM education was developed following a three-tier qualitative data analysis of interview transcripts and observation notes. In-depth interviews with school administrators and teachers, reinforced data gathered from classroom observations in various STEAM classes conducted across 33 Higher Education Institutions (HEIs) all over the country. Findings showed that the STEAM Pedagogical Model in Philippine HEIs demonstrates an interdependence between Institutional Pedagogical Culture and STEAM Pedagogical Processes. The pedagogical culture of an HEI pertains to its framework and mechanism for planning, disseminating, and evaluating the pedagogical processes and the extent by which research and teaching nexus is advanced in all these processes. The pedagogical culture of an HEI drives its STEAM pedagogical processes, specifically the teaching practices, and shapes the pedagogical character of its teachers. A teacher's epistemological beliefs and teaching practices comprise, better yet, reflect his/her pedagogical character. STEAM teachers acknowledge the absence of perfect teaching strategy to suggest that appropriateness of teaching approach must be given attention in planning the pedagogical processes. Hence, STEAM teachers are skilled in various teaching strategies and adept in switching across strategies whenever appropriate and necessary. Equally, STEAM teachers model learning by linking practice and teaching, and demonstrating critical and reflective thinking. The Pedagogical model of Philippine STEAM Education explicates that the synergy between an institution's pedagogical culture and its pedagogical processes is gauged by the quality of its learners and teachers. Specifically, Philippine STEAM education aims at nurturing critical thinkers, productive citizens, and competent STEAM professionals.

Keywords: epistemological beliefs, illustration of practice, pedagogical model, pedagogical culture, proficiency continuum

2.1. The Model Defined

This section articulates the compelling reasons why a study on Philippine model of STEAM education is cogent and relevant to current times. It also provides a general background of the model, what the model is all about and what it is not, its salient features, what is new in the model, and its very purpose.

2.1.1. Why the Model

The multi/inter/transdisciplinary nature of Science, Technology, Engineering, Agri-Fisheries, and Mathematics (STEAM) advances understanding of the world as a whole rather than as fragments of isolated realms. STEAM Education then necessitates teachers to have a multi/inter/transdisciplinary grasp of STEAM. This entails loosening one's exclusive disciplinary identity, going out of one's comfort zone, and demonstrating holistic understanding of how Science, Technology, Engineering, Agri-Fisheries, and Mathematics shape each other. Translating the holistic view of STEAM into STEAM pedagogical processes results in products and outcomes that drive the global economy and industry. We owe most of the innovations and inventions to STEAM thinkers (e.g. practitioners, educators). In demand skills and jobs are all in STEAM - data science, software engineering, robotics, etc... This interconnection suggests that STEAM-competent teachers are in high demand.

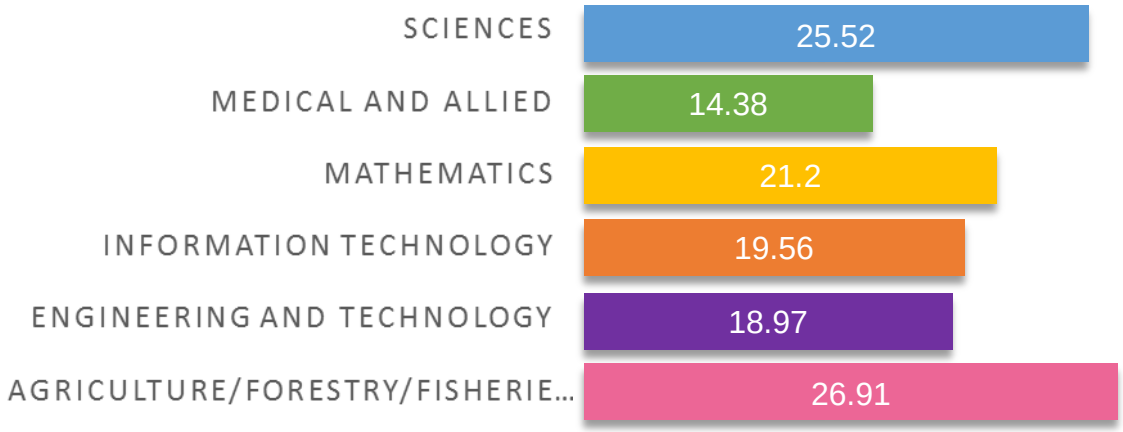

Figure 2.1. Completion rate (%) across STEAM areas calculated from a 5-year data until SY 2016-2017. Source of Data: Commission on Higher Education

However, the Philippines falls short of STEAM graduates. CHED data (Commission on Higher Education, 2019) on completion rates (Figure 2.1) across STEAM areas show that STEAM programs indexed an average completion rate of 21%. In 2016, for example, of the 645,973 university graduates, only 12% obtained a degree in engineering, mere 1% in science and dismal 0.4% in mathematics. The dearth of STEAM graduates manifests as shortage of scientists. At 189 scientists per million, the Philippines lags behind the UNESCO

recommendation of 380 per million (Jalea, 2018), a figure way lower than that of its neighboring ASEAN countries - Vietnam at 674 per million, Thailand at 974 per million, and Malaysia at 2,100 per million.

The scarcity of scientists in the Philippines is greatly felt in various productivity metrics. In agriculture, for example, the total factor productivity of the Philippines registers 1.87%, way much lower than that of Vietnam at 2.53% and Malaysia at 2.85% (Jalea, 2018). The total factor productivity or agricultural productivity is a comparative measure between agricultural resources (e.g. land, labor, materials) and total crop and livestock production. In terms of agricultural trade (export versus import), the latest UN Trade Map data, as cited in Jalea (2018) showed that the Philippines registered a deficit of $5B versus the $9.3B and $26.5B respective surplus of Malaysia and Thailand. All these point to the unfavorable conditions obtaining in STEAM education in the country, particularly on the quality of STEAM teachers. Research shows that an increase in the number of STEAM-competent teachers raises the number of students going into STEAM fields (Business-Higher Education Forum, 2010). Studies further show that STEAM proficiency of teachers affects students' STEAM proficiency (Gordon, Kane, & Staiger, 2006; Hanushek, 2002). Data from World Economic Forum, as cited in Oxford Business Group (2018), also reveal that the quality of Mathematics and Science Education in the Philippines ranks among the lowest regionally, resulting in relatively low number of STEM graduates. Responding to this deficiency, the Philippine Commission on Higher Education (CHED) identified Education for STEAM as one of its Research priority areas. Such realities necessitate a study that models the current practices of STEAM education in the country to develop or amend relevant policies and standards, as regards the country's STEAM programs.

2.1.2. The Model is…

The Pedagogical Model for Philippine STEAM Education (PMPSE) represents the current pedagogical perspectives and practices of Philippine STEAM administrators and teachers. Specifically, the analysis focused on exploring the various domains of STEAM pedagogical processes, as practiced by Philippine higher education institutions (HEIs). The PMPSE represents the antiquated view of Philippine HEIs on STEAM education.

2.1.3. The Model is NOT…

The PMPSE may not model an ideal STEAM pedagogy in the Fourth Industrial Revolution (4IR). An examination of literature on the possibilities, opportunities, and disruptions brought about by the 4IR on business and industry points to the acute need for HEIs to have a relatively radical shift in the educational contour. Also, literature review conducted attempted to extrapolate the PMPSE domains into the conditions and requirements of the 4IR.

2.1.4. What is new about the Pedagogical Model?

The PMPSE intensifies the nexus between institutional pedagogical culture and pedagogical practices. The model emphasizes how institutions shape the outcomes of learning via their pedagogical ideals and practices. It also underscores the tripartite synergy among HEIs, industry, and community.

2.1.5. Salient Features of the Model

The PMPSE represents the current pedagogical perspectives and practices of Philippine STEAM administrators and teachers. More deeply, the model:

- articulates the various epistemological and ontological perspectives drawn from the data sources (i.e. HEI administrators, STEAM Program Coordinators, STEAM Teachers), as shown in their beliefs, ideas, and practices;
- accentuates the interdependence between an institution's pedagogical culture and STEAM pedagogical processes;
- explicates the synergy between an institution's pedagogical culture and its pedagogical processes as gauged by the quality of its learners and teachers; and
- revisits the STEAM pedagogical practices of HEIs to identify gaps with the requirements of the 4IR.

2.1.6. What is the Pedagogical Model

The Pedagogical Model of Philippine STEAM Education (PMPSE) articulates the various epistemological and ontological perspectives drawn from the data sources (i.e. HEI administrators, STEAM Program Coordinators, STEAM Teachers), as manifested in their beliefs, ideas, and practices. It accentuates the interdependence between an institution's pedagogical culture and STEAM pedagogical processes. The pedagogical culture of a Higher Education Institution (HEI) refers to its framework and mechanism for planning, disseminating, and evaluating the pedagogical processes and the extent by which research and teaching nexus is advanced in all these processes. Planning the pedagogical processes specifically ensures alignment of learning objectives with activities, alignment of faculty specialization with content taught, partnership between school and industry, and emphasis of the relevance of STEAM to the community. An institutional pedagogical culture equally demands disseminating institutional pedagogical policies and curricular reforms, programs, and innovations. Evaluation of pedagogical processes entails not only periodic institutional review of curriculum but also of teachers' pedagogical processes and consequently drawing implications for ranking, promotion, and continuing professional development. Pedagogical culture further promotes mentoring among faculty members, tenders continuing professional development opportunities for teachers.

The pedagogical culture of an HEI drives its STEAM pedagogical processes, specifically the teaching practices, and shapes the pedagogical character of its teachers. As illustrated by the **yin-yang** construct, the institutional pedagogical processes and teachers' pedagogical character exemplify the institution's pedagogical culture. This stance suggests that pedagogical processes exact planning, facilitating, and monitoring learning, as well as establish a mentoring mechanism for learners. More importantly, the Philippine STEAM pedagogical model emphasizes inquiry-based and output/product-based learning and teaching and a spectrum of related teaching practices. By extension, it promotes ethical conduct of STEAM pedagogical processes and research for continuous improvement of STEAM pedagogy.

A teacher's epistemological beliefs and teaching practices reflect more than his/her pedagogical character. STEAM teachers acknowledge that there is no such thing as a perfect teaching strategy. This axiom suggests that appropriateness of teaching approach must be given attention in planning the pedagogical processes. Hence, STEAM teachers are skilled in various teaching strategies and adept in switching across strategies whenever appropriate and necessary. Ideally, STEAM teachers model learning by linking practice and teaching and demonstrating critical and reflective thinking that redound to the learners' benefit.

The Pedagogical model of Philippine STEAM Education explicates that the synergy between an institution's pedagogical culture and its pedagogical processes is gauged by the quality of its learners and teachers. In particular, Philippine STEAM education aims at nurturing critical thinkers, productive citizens, and competent STEAM professionals. The circular frame of the model depicts sustainability of every relationship demonstrated by its variables and dimensions.

2.2. Alignment of the Pedagogical Model to TPACK, PPST and PSG

Crafting the Pedagogical Model for Philippine STEAM Education attunes to Quality Tertiary Education consequently aligned to the Philippine and Asian quality standards for quality assurance; and to the themes of *"AMBISYON NATIN 2040:" "Matatag, Maginhawa, at Panatag na Buhay* (Philippine Development Plan [PDP], 2017)." The country holds that the 2040 goal may be concretized through the three priority areas of the crafted Philippine Development Plan which includes: 1) *malasakit* (enhancing social fabric); 2) *pagbabago* (reducing inequality); and 3) *patuloy na pag-unlad* (sustaining growth potential). These three priority areas stress, among other things, the promotion and awareness of Philippine culture, acceleration of human capital development, promotion of technology, and stimulation of innovation. Seemingly, the vision of PDP framework underscores the need for pedagogical model to direct all pedagogical workings within the envisioned quality Philippine STEAM education as among the cores to achieving the 2040 goals.

Apparently, the Philippine Pedagogical Model defines quality in the envisioned Philippine STEAM Education by being aligned to and defined by the three major frameworks that inform the Philippine Higher Education: TPACK Framework, Policies, Standards, and Guidelines, and the Philippine Professional Standards for Teachers. In details, TPACK defines the pedagogical processes of STEAM teachers through technology integration, innovative pedagogical approaches, appropriate assessment tools, and content standards and competencies, covered by the sub-leveled dimensions such as teaching practices and pedagogical character of STEAM teachers. The Institutional Pedagogical Culture variable of the PMPSE informs how the reviewed 46 PSGs influenced crafting of the PSME to suit almost all possible and unique attributes of all the STEAM programs laid in the PSGs. Finally, PPST heavily influenced the other variables (STEAM Teaching Practices and Outcomes of STEAM Education).

2.3. Purposes of the Pedagogical Model

The PMPSE was developed to document the current practices of Philippine HEIs as regards STEAM education. Primarily, the PMPSE aims to inform the higher education institutions on the current practices beliefs among its administrators and teachers on specific aspects of STEAM education. The model also seeks to inform the Commission on Higher Education on the position of Philippine STEAM education in the 4IR.

2.4. The Model Explained

This section expounds each domain of the model through descriptions, explanations, illustrations of practice, and continuum of practice.

2.4.1. Domain Overview

2.4.1.a. The Institutional Pedagogical Culture

The institutional pedagogical culture refers to the institutional policies, infrastructure, and practices that support the pedagogical processes and requirements of the faculty and staff. The Pedagogical Model of Philippine STEAM Education (PMPSE) valorizes the need for an institutional mechanism in planning, disseminating, and evaluating the pedagogical processes.

Planning the pedagogical processes entails instituting a mechanism that engages the faculty and staff across all departments and units in a periodic review of the curriculum, specifically on the alignment of learning objectives, activities, and assessment. Planning involves developing a system to maximize involvement of the faculty and staff across disciplines in all institutional initiatives to fine tune the curriculum. In this regard, curriculum here is seen as an overarching element that encompasses the pedagogical processes such that understanding the pedagogy first requires a good grasp of the curriculum. Curriculum review constitutes

alignment of the learning objectives with activities, course requirements, and alignment of the STEAM content with the teachers' field of specialization. As revealed during school visits and interviews, some Philippine HEIs task teachers to teach content areas which are outside their field of specialization. A case in point is that of a licensed nurse teaching modern Physics in a school in a Teacher Education cohort. While this incident may not be a concern in a STEAM-based curriculum, the problem arises when some teachers lack the necessary competencies to teach the course as a result of a highly discipline-based curriculum. For instance, while we envision our graduates of a Physics degree to be considerably competent in other STEAM disciplines, when harsh reality reminds us that these graduates were trained in a highly Physics-based curriculum thereby possessing the competencies exclusively identified in a Physics degree. Planning the pedagogical processes also necessitates HEIs to ensure that the STEAM curriculum advances school-industry partnership and stresses the relevance of STEAM to the society. This motion suggests that HEIs establish strong linkages with industry partners as well as with the community. The PMPSE underscores the need to involve these stakeholders in all major curricular modifications or innovations of an HEI. For example, shifting to an outcomes-based curriculum must necessarily involve the industry partners and the community in every stage of the transition to suggest that HEIs fairly institute a mechanism where pedagogical decisions are properly communicated to all probable stakeholders.

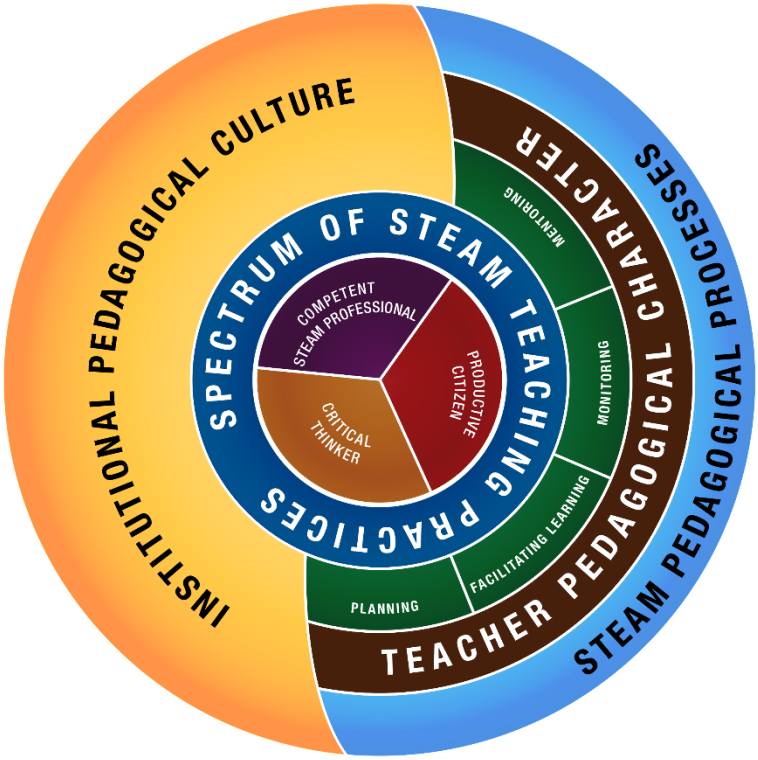

Figure 2.2 The Pedagogical Model of Philippine STEAM Education

Disseminating pedagogical processes relates to an institutional mechanism to diffuse pedagogical innovations, programs, and policies to all stakeholders. It entails making sure that

pedagogical policies and standards are communicated and understood by its main implementers. This function further means that faculty and staff, the industry partners, and the community are not only fully aware of the pedagogical goals of the HEI, but also stress their responsibility and accountability towards quality STEAM education. It also implies that evaluation of the pedagogical processes involves the stakeholders as well.

Evaluating pedagogical processes means that an institutional mechanism has taken its rightful place in monitoring and assessing planned pedagogical processes. It involves regular institutional review of the curriculum, which serves as basis for further planning of pedagogical processes, and evaluation of teachers' pedagogical plans and their implementation. HEIs must see to it that evaluation data are significantly considered for any relevant academic and administrative decisions including teachers' continuing professional development and ranking, promotion, and retention.

The pedagogical culture of an institution further extends its scope to institutional support to pedagogical processes, primarily in the area of professional development. Such institutional support–moral or financial–to professional development demands allocating funds for professional development programs and activities such as trainings and capacity building workshops and benchmarking of best practices from other HEIs with reputable STEAM programs. Support to professional development also includes establishing an institutional mentoring mechanism among faculty and staff such as Senior-Junior Faculty mentoring program.

2.4.1.b. The Teacher's Pedagogical Character

As the PMPSE posits that the pedagogical culture of an institution shapes the pedagogical character of STEAM teachers, the latter consequently upholds the former and vice versa. This dualist interaction manifests as STEAM pedagogical processes where a spectrum of STEAM teaching practices is grounded. The pedagogical character of a STEAM teacher specifically refers to his epistemological beliefs and teaching practices. For instance, as noted earlier, Philippine STEAM teachers acknowledge that there is no such thing as perfect teaching strategy so that the effectiveness of a strategy can never be replicated. This idea implies that a teaching strategy is effective only at the very moment it was proven effective. It is imperative then that every STEAM teacher becomes adept in employing a strategy that suits the content and the context of learners and learning circumstances.

The teachers' pedagogical character is also demonstrated through modeling of learning that entails conducting STEAM research, sharing one's experiences, linking practice to teaching, and demonstrating critical and reflective thinking. The collected data revealed that STEAM practitioners, or those with industry experiences, are preferred to teach the STEAM courses, as they are able to integrate application of concepts to real industry processes by invoking their own experience. Questioning skills also indicate one's pedagogical character. STEAM teachers are assumed to be skilled considerably in straddling through questions across different

difficulty levels that entail skillful use of, and management of reply to, probing questions, converging questions, impromptu questions, and queries that require higher order thinking skills. Data also yielded that increasing the complexity of questions during recitations significantly helps students grasp and appreciate the lesson's nuances. It can be deduced that a teacher's pedagogical character translates into actual teaching practices. The succeeding section models the teaching strategies of Philippine STEAM teachers.

2.4.1.c. STEAM Teaching Practices

Consistent with pedagogical character, STEAM teachers are assumed to be skilled in various teaching strategies and adept in switching across approaches and techniques whenever appropriate and necessary. This study looked into the current teaching practices of Philippine STEAM teachers. Data showed that generally, teaching STEAM courses is characterized by inquiry-based and collaborative learning with more weight placed on students' outputs or products. STEAM teaching as an inquiry-based learning process particularly suggests that modeling learning must manifest in the learning process. Building from what has been discussed in the previous section, modeling learning underscores the teachers' ability to provide live applications of STEAM concepts. This practice includes (1) simulations of actual applications, (2) illustration of real-life examples, (3) facilitation of a life-like experiences, (4) integration of values, and (5) application of concepts in solving problems in the raw. Specifically, such a scheme involves (1) virtual modeling and computer simulations, (2) site visits to industries, and (3) problem-based and project-based learning, and the (4) development of values and life skills in such processes. Apparently, teaching STEAM is characterized by a wide spectrum of output-based and collaborative teaching strategies. Hence, teachers must be skilled in facilitating group activities which may demand establishment of grouping policies and guidelines.

Collaborative learning is preferred in teaching STEAM because students share knowledge and demonstrate skills to fellow students rather than to their teachers. Interestingly, PMPSE deems the lecture method an important teaching strategy for STEAM. It is believed that it gives teachers the opportunity to underscore (repeat) the least learned concepts.

Teaching STEAM is also characterized by the conscious incorporation of the learners' prior knowledge in the pedagogy. STEAM teachers elicit prior knowledge primarily to draw out the learners' conceptual background as an input to any possible deviation from the planned lesson scope, pacing, and strategy. Specifically, eliciting prior knowledge or schema entails dealing with alternative conceptions with respect and utilizing the learners' naive ideas as springboard to the discussion. Data further showed that STEAM pedagogical processes must provide learners opportunities to develop and strengthen their communication skills. In particular, learners are goaded to express their grasp and appreciation of concepts in their own words, better yet, grapple with the bull's horn, so to speak.

Emerging as an essential pedagogical process for STEAM, research in STEAM is two-pronged. PMPSE posits that STEAM teachers must be actively doing researches both in STEAM field and in STEAM Education. While research on STEAM (multidisciplinary, inter/intradisciplinary, transdisciplinary) is deemed vital in modeling learning, research on STEAM pedagogy bridges the perceived pedagogical gap among STEAM specialists (i.e., graduates of STEAM degrees and not of STEAM education degrees) who are commonly stereotyped to be poorly wanting in pedagogical strategies, as they tend to be highly conceptual and theoretical in their approach. If at all, they are perceived to show little concern about the learners' context (e.g., conceptual background, schema or prior knowledge, learning preferences) and the learning circumstances. PMPSE postulates that conducting iterative researches about STEAM teaching, as well as integrating the outputs of STEAM research in the pedagogy, conjointly establish the foundation of quality STEAM education.

Planning the Learning Process

The PMPSE highlights the support of teachers to institutional mechanism in planning the STEAM pedagogical processes. It calls for active involvement of STEAM teachers to institutional efforts in curriculum development and review thereby ensuring strong school-industry-community partnerships. Specifically, STEAM teachers plan the teaching strategies, approaches, and methods vis-a-vis the course objectives, competencies required, and institutional pedagogical goals. STEAM teachers likewise plan the learning process to ensure that teaching strategies are responsive to the diverse learning contexts. The PMPSE also finds it crucial to ensure that the teacher assigned to handle a particular STEAM course possesses the competencies that the course aims to develop among the learners. This implication suggests that more than the possession of the competencies, PMPSE prefers teachers who have experienced the practical application of STEAM concepts such as in industries and services sectors.

Facilitating the Learning Process

The PMPSE emphasizes the significance of facilitating learning in ensuring success in the learning of STEAM. Facilitating learning is seen as an integral component of STEAM learning such that planning the pedagogical processes must duly consider how learning may be maximized, a desideratum implying that facilitating learning has to be embedded in every STEAM teacher's pedagogical processes.

Facilitating learning primarily seeks to promote a positive relationship with learners and maintain a positive learning environment in creating a friendly environment with learners while maintaining authority over them. This notion may involve dealing with struggling learners with patience and being considerate in giving course requirements and projects, especially those that involve expenses. Promoting a positive relationship with learners also means helping the learners build self-confidence and motivating them to learn how to learn, to use Dellor’s phraseology. STEAM teachers must inspire their learners. They impose high, great

expectations on learners and encourage them to do more and to be better achievers. Teachers inspire learners to appreciate learning for its own sake, as John Dewey aptly puts it. The PMPSE affirms that in a STEAM classroom, teachers are keen at appreciating efforts and academic milestones of learners. This quality entails giving credits whenever due and appropriate. It also requires appreciating learners' curiosity. Facilitating learning also involves classroom organization where students in every class assume specific responsibilities such as disseminating information and announcements. It also requires imposing classroom rules and regulations, observing class routine, and monitoring learners during discussions and class activities. For example, STEAM teachers must ensure that laboratory rules and guidelines are considerably observed during laboratory classes to avoid untoward incidents.

Monitoring the Learning Process

STEAM teachers very consciously monitor the learning process and learning circumstances. This suggests that teachers follow up on the classroom processes and the learners' acquisition of knowledge and development of skills and values, entailing development of assessment tools. Monitoring learning advances that learners must be fully aware and conscious of the assessment standards. Expectedly, the assessment tools must provide learners the opportunity to explore the various applications of STEAM concepts through varied problems. This need implies that assessment tools for STEAM ought to simulate solving actual problems in the field. STEAM teachers must be keen in making sense of the assessment results that inform the mentoring mechanism, the subsequent learning processes such as lesson pacing and scope, and more important, even the institutional STEAM pedagogical processes.

Mentoring the Learners

Mentoring is deemed crucial in the success of teaching STEAM. Besides mentoring among faculty and staff, the PMPSE advocates establishing an institutional mentoring mechanism for students. It specifically demands having rooms dedicated for mentoring activities as well as including the mentoring sessions as official function of every faculty whereby certain number of mentoring hours will be dedicated or considered as official time. Mentoring is viewed as seamless and borderless such that students may sign up for a mentoring session with any faculty he/she deems fitting and proper to address his/her concerns. The mentoring process in PMPSE primarily aims to address students' difficulty in understanding the lessons.

2.4.1.d. The Outcomes of STEAM Education

The PMPSE advances the stance that the mutual support between institutional pedagogical culture and the teachers' pedagogical character, as demonstrated by the STEAM pedagogical processes, nurtures learners expected to graduate as life-long critical thinkers, competent STEAM professionals, and productive citizens. Specifically, STEAM graduates are trained to planning and executing probable solutions to pressing societal problems which involve

modeling and communicating ideas. A competent professional is able to achieve the discipline-based requirements such as passing the licensure examination and relevant accreditations. Competent STEAM professionals primarily are those who tender significant contributions to programs and initiative that improve the quality of life. This spectrum involves research, production, and application of useful knowledge, products and services.

The Pedagogical Model of Philippine STEAM Education illustrates the interdependence between an institution's pedagogical culture and STEAM pedagogical processes. Specifically, the institutional pedagogical culture is considered the key driver to STEAM pedagogical processes, which consequently shape the former. The model elucidates that STEAM teachers and teaching practices play a critical role in ensuring quality of STEAM education in the country. The succeeding section presents the proficiency indicators of STEAM teachers, as drawn from the model.

2.4.2. Continuum of Practice

The model articulates the characteristics of STEAM educators based on the analysis of generated responses and observed practices among data sources. Specifically, the model clarifies four proficiency levels of STEAM educators - the Novice (Awareness) level, the Proficient (Proactive Awareness) level, the Highly Proficient (Modeling) level, and the Distinguished (Inspiring/Mentoring) level. A sample elaboration of proficiency among STEAM teachers is presented in Table 2.1., the full description of each level of the continuum presented in Appendix II.A.

Table 2.1. Proficiency continuum for STEAM Educators in the area of Monitoring of Learning

Novice (Awareness)	Proficient (Proactive Awareness)	Highly Proficient (Modeling)	Distinguished (Inspiring/Mentoring)
Novice STEAM Educators possess knowledge of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement; manifest capability of using	Proficient STEAM Educators promote the effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement; and promote the effective use of assessment data to address challenges	Highly Proficient STEAM Educators model effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement; and model the	Distinguished STEAM Educators mentor other STEAM Educators on the effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement, as well as the effective use of assessment data to

assessment data to address challenges in implementing effective teaching and learning practices.	in implementing effective teaching and learning practices	effective use of assessment data to address challenges in implementing effective teaching and learning practices	address challenges in implementing effective teaching and learning practices

2.4.3. Suggested Resources

The PMPSE advances a synergy among administrators, faculty, and staff within HEIs and among HEIs, Industry, and Community. Like any other synergistic approach to change and improve services, the model implies allocating sufficient budget for the advancement of STEM. To illustrate, in terms of teacher professional development, HEIs must ensure that sufficient budget is set aside for the training, reskilling, and upgrading of faculty members' competencies.

2.4.4. Illustration of Practice

STEAM education practices among administrators and teachers are modeled in a form of proficiency continuum (see Appendix II.A). The specific practices and indicators are also captured in Appendix II.B.

APPENDICES

Appendix II. A. Proficiency Continuum for STEAM Educators

Novice (Awareness)	Proficient (Proactive Awareness)	Highly Proficient (Modeling)	Distinguished (Inspiring/Mentoring)
Novice STEAM Educators acknowledge the need for a culture of support to institutional mechanism in planning, implementing, and evaluating pedagogical processes, ensure alignment of learning objectives and activities, advancing school and industry partnerships, emphasizing the relevance of STEAM to society, and instituting continuous improvement in curricular policies and practices.	Proficient STEAM Educators promote a culture of support to institutional mechanism in planning, implementing, and evaluating pedagogical processes, ensure alignment of learning objectives and activities, advancing school and industry partnerships, stressing the relevance of STEAM to society, and instituting continuous improvement in curricular policies and practices.	Highly Proficient STEAM Educators exemplify a culture of support to institutional mechanism in planning, implementing, and evaluating pedagogical processes, ensure alignment of learning objectives and activities, advancing school and industry partnerships, focusing on the relevance of STEAM to society, and instituting continuous improvement in curricular policies and practices.	Distinguished STEAM Educators nurture a culture of support to institutional mechanism in planning, implementing, and evaluating pedagogical processes, ensure alignment of learning objectives and activities, advancing school and industry partnerships, accenting the relevance of STEAM to society, and instituting continuous improvement in curricular policies and practices.
Novice STEAM Educators acknowledge the need to model learning, and to demonstrate critical and reflective thinking.	Proficient STEAM Educators promote learning-by-modeling and demonstrate critical and reflective thinking.	Highly Proficient STEAM Educators exemplify learning-by-modeling and demonstrate critical and reflective thinking.	Distinguished STEAM Educators lead and inspire other STEAM educators in exemplifying learning-by-modeling, and demonstrating critical and reflective thinking.
Novice STEAM Educators possess knowledge of teaching strategies and manifest capacity to manage learning activities that promote learning based on learners' needs.	Proficient STEAM Educators manifest the use of wide range of teaching strategies that promote STEAM literacy and other skills by actively engaging in collaborative learning with the professional community and other stakeholders for mutual	Highly proficient STEAM Educators collaborate with colleagues in applying research-based pedagogy that promote inquiry, problem- and product-based learning, curriculum planning, management of learning, and valuable use of technology to create lifelong impact in the lives of other STEAM	Distinguished STEAM Educators champion modelling and mentoring of research-based pedagogy that promote inquiry, problem- and product-based learning, curriculum planning, management of learning, and valuable use of technology to create lifelong impact in the lives of other STEAM

	growth and advancement.	professionals, colleagues, diverse learners/students and the community.	professionals, colleagues, diverse learners/students and the community.
Novice STEAM Educators possess knowledge of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement, manifest capability in using assessment data to address challenges in implementing effective teaching and learning practices.	Proficient STEAM Educators promote the effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement, as well as promote the effective use of assessment data to address challenges in implementing effective teaching and learning practices	Highly Proficient STEAM Educators model effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement, as well as model the effective use of assessment data to address challenges in implementing effective teaching and learning practices	Distinguished STEAM Educators mentor other STEAM Educators on the effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement, as well as the effective use of assessment data to address challenges in implementing effective teaching and learning practices
Novice STEAM Educators acknowledge the need to develop a structured academic consultation mechanism to address learners' difficulty.	Proficient STEAM Educators promote having a structured academic consultation mechanism to address learners' difficulty.	Highly Proficient STEAM Educators model effective conduct of academic consultation as evidenced by the learners' improvement.	Distinguished STEAM Educators mentor colleagues on the effective conduct of academic consultation, as evidenced by the learners' improvement.
Novice STEAM Educators recognize the need to promote positive relationship with learners in an environment conducive to learning, thereby inspiring learners to aim for excellence.	Proficient STEAM Educators promote positive relationship with learners in an environment conducive to learning, thereby inspiring learners to aim for excellence.	Proficient STEAM Educators model positive relationship with learners in an environment conducive to learning, thereby inspiring learners to aim for excellence.	Proficient STEAM Educators inspire other STEAM educators to promote positive relationship with learners in an environment conducive to learning, thereby inspiring learners to aim for excellence.
Novice STEAM Educators acknowledge the need to conscientiously plan the pedagogical processes towards effective use of knowledge, skills and values to support the STEAM teaching and learning process.	Proficient STEAM Educators promote conscientious planning of pedagogical processes towards effective use of knowledge, skills and values to support the STEAM teaching and learning process.	Highly Proficient STEAM Educators models conscientious planning of pedagogical processes towards effective use of knowledge, skills and values to support the STEAM teaching and learning process.	Distinguished STEAM Educators inspires colleagues to conscientiously plan the pedagogical processes towards effective use of knowledge, skills and values to support the STEAM teaching and learning process.
Novice STEAM Educators understand that critical thinking	Proficient STEAM Educators promote acquisition,	Highly Proficient STEAM Educators model pedagogical processes	Distinguished STEAM Educators inspire other STEAM educators to

among learners characterizes quality education and that STEAM pedagogical process must provide learners the opportunity to acquire, demonstrate, and evaluate critical thinking.	demonstration, and evaluation of critical thinking among learners in all pedagogical process.	that put premium on acquisition, demonstration, and evaluation of critical thinking among learners.	model pedagogical processes that put premium on acquisition, demonstration, and evaluation of critical thinking among learners.
Novice STEAM Educators acknowledge the need to consciously integrate in the pedagogical processes, whenever cogent and relevant, the development of knowledge, skills, and values that could help prepare learners pass the licensure examination.	Proficient STEAM Educators promote the conscious integration in the pedagogical processes, whenever cogent and relevant, the development of knowledge, skills, and values that could help prepare learners pass the licensure examination.	Highly Proficient STEAM Educators model the conscious integration in the pedagogical processes, whenever cogent and relevant, the development of knowledge, skills, and values that could help prepare learners pass the licensure examination.	Distinguished STEAM Educators mentor other STEAM educators the conscious integration in the pedagogical processes, whenever cogent and relevant, the development of knowledge, skills, and values that could help prepare learners pass the licensure examination.
Novice STEAM Educators acknowledge the need to prioritize in all pedagogical processes the development of skills, knowledge, and values required of the profession thereby enhancing employability and work success of graduates.	Proficient STEAM Educators promote prioritizing the development of skills, knowledge, and values required of the profession thereby enhancing employability and work success of graduates.	Highly Proficient STEAM Educators model prioritizing the development of skills, knowledge, and values required of the profession thereby enhancing employability and work success of graduates.	Distinguished STEAM Educators mentor other STEAM educators on prioritizing the development of skills, knowledge, and values required of the profession thereby enhancing employability and work success of graduates.

Appendix II.B. Indicators of Practices for STEAM Domains

Domain	Elaboration	Illustration of Practice
Institutional Pedagogical Culture	Institutional Pedagogical Culture refers to institutional practices that support the pedagogical process and requirements of faculty and staff. The model proposes an institutional mechanism in planning, disseminating, and evaluating pedagogical processes. Planning the pedagogical processes entails the following: 1. Involvement of faculty and staff across all disciplines to align learning objectives and activities. 2. Alignment of teacher's field of specialization and course content to teach. 3. Ensuring that pedagogical processes advance school-industry partnership. 4. Ensuring that pedagogical processes stress the relevance of STEAM Education to community. Evaluating pedagogical processes means that an institutional mechanism is in place for monitoring and evaluation of planned pedagogical processes. It entails: 1. Regular institutional evaluation of curriculum 2. Evaluation of teachers' pedagogical plans – A staff (e.g. coordinator) is assigned. 3. Evaluation of teachers' implementation of pedagogical plans. 4. Results of evaluation serve as basis for ranking, promotion, and retention. 5. Results of evaluation serve as basis for teacher professional development programs The institutional support to pedagogical processes primarily refers to institutional support for faculty development. Support for faculty development means the institution: 1. provides funds for teacher professional development such as attendance to trainings 2. has a mentoring program between senior and junior faculty members 3. collaborates with other HEIs with reputable STEAM programs	Institutional Annual Review and Calibration of Curriculum Regular Meeting with Industry Partners and Community Leaders Classroom Observation Specialization Mapping Orientation, Convocation, and Symposium Faculty Development Programs Ranking and Promotion Faculty Mentoring Program Collaboration - Twinning
Teacher Pedagogical Character	This refers to the teachers' epistemological beliefs and pedagogical practices. 1. teacher acknowledges the diversity of teaching strategies. Anchored on the idea that "there is no perfect teaching strategy", suggesting that appropriateness of strategy must be considered: "it's not always because sometimes it's not the most appropriate to use" 2. teacher models learning *a.* shares his/her experiences *b.* links practice and teaching *c.* demonstrates critical and reflective thinking. Questioning skills are also observed.	Survey of Student needs and preferences Conducts Action Research Educational Trips Recitation

STEAM Teaching Practices	The pedagogical processes currently employed by Philippine STEAM teachers in teaching STEAM courses, primarily the teaching approaches and corresponding teaching techniques. The following emerged as current practices of STEAM teachers: 1. Inquiry-Based Learning – teachers employ inquiry-based learning a. Real-life applications - Teacher's pedagogical processes provide life-like applications of lessons 2. Output-Based Learning – Whenever appropriate (there are disciplines like engineering that are highly output-driven), the teacher gives more weight to learner's output than the process. 3. Lecture Method. The teacher's pedagogical processes include use of lecture method deemed important in teaching STEAM courses, specifically in the tertiary level. It gives teachers the opportunity to repeat (underscore) important topics 4. Collaborative Learning. Facilitating group activities is evident in the teacher's pedagogical processes. a. Grouping policies and guidelines b. Collaborative learning is employed because students tend to share knowledge more to fellow students than to the teacher. General: 1. Elicits prior knowledge. Teacher's pedagogical processes include dealing with prior knowledge appropriately. Primarily, eliciting schema means drawing out the learner's background or previous knowledge and conducting a short review before proceeding to the next topic. 2. Strengthens learners communication skills. The teacher's pedagogical processes strengthen the learner's communication skills (English and Filipino) 3. Teacher does action research to ensure that pedagogical practices are relevant and effective. Teacher's pedagogical processes include monitoring learner's acquisition of knowledge. 1. warns students who get low scores in test 2. seeks learner's commitment to do well in class 3. adjusts teaching techniques based on learner's progress Monitoring of learners' acquisition of knowledge also entails ability to develop assessment tools. Teacher develops test items not lifted directly from the materials used in class. Crucial also in monitoring acquisition of knowledge is making the learners aware of the assessment standards. Teacher's pedagogical processes include a regular consultation schedule to address learners' difficulty. 1. a room is dedicated for mentoring sessions 2. teacher is open to mentor any student in the school, anytime 3. consultation time is structured Management of classroom processes is embedded in the teacher's pedagogical processes. It entails classroom organization where the teacher delegates tasks and responsibilities to class officers as in disseminating information or announcements, imposing classroom	Use of Scaffolding and GRR Employs Learning by Modeling Employs Simulations Employs problem-based, output-based, project-based, outcome-based learning Employs Lecture Method Provides group tasks Conducts Review prior to lesson Code switching in using language Recitation Conduct of Action Research Consultation and Conference with Students Employs Authentic Assessment Conducts structured mentoring and consultation Class Organization (with Class Officers) Imposes classroom and laboratory rules

	rules and regulations, observing class routine, and monitoring learners during discussion and class activities.	
Outcomes of STEAM Education	STEAM teachers treat critical thinking as an outcome of STEAM pedagogical processes 1. graduates are trained to offer solutions to any problem 2. learners must know how to explain solution to a problem 3. learners are able to model a problem e.g. diagrams, pictures, grid, etc. 4. learners learn the concept that is applicable to solve a problem, not the specific formula appropriate to a specific problem 5. learners are exposed to many possible solutions to a problem Teacher's pedagogical processes prepare students for the licensure examination Teachers underscore employability of graduates as outcomes of the pedagogical processes	Field Trips Employing models Apprenticeship [Students] Passing the licensure examination Conducting a Tracer Study

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