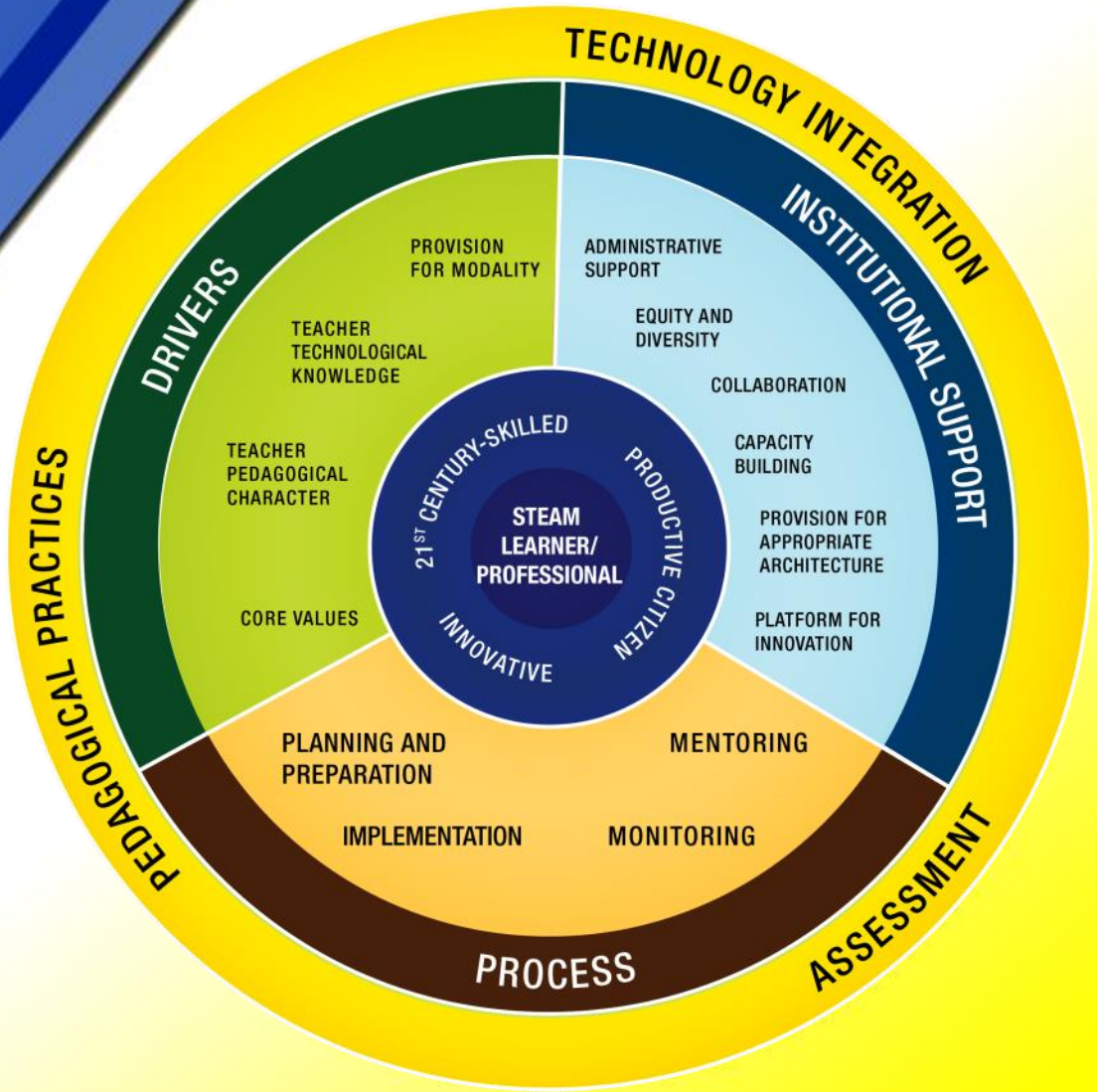
THE PHILIPPINE STEAM EDUCATION MODEL

TPACK IN PHILIPPINE STEAM EDUCATION 2017-2019

CHED - PNU
TPACK
STEAM EDUCATION



TPACK
in
Philippine
STEAM Education

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- Outcomes-based Education
- TPACK Framework
- Philippine Professional Standards for Teachers
- The Philippine STEAM Education Pedagogical Model
- Assessment Model of the Philippine STEAM Education
- Technology Integration Model of the Philippine STEAM Education

CONTENTS

INTRODUCTION

The Philippine Development Plan (PDP 2017-2022) underscores specific strategic goals and development processes of the Philippine government to realize the envisioned future of every Filipino to enjoy "*Matatag, Maginhawa, and Panatag na buhay*." The country believed that the 2040 goal (spelt out as *AmbisyonNatin* 2040) may be concretized through the three priority areas of the development plan, which includes: 1) *malasakit* (enhancing social fabric); 2) *pagbabago* (reducing inequality); and 3) *patuloy na pagunlad* (increasing growth potential). These three priority areas emphasize among others promotion and awareness of Philippine culture, acceleration of human capital development, promotion of technology, and stimulation of innovation. Apparently, the make-up of the PDP framework puts STEAM as among the cores to achieving the 2040 goals. Thus, necessitates cross-cutting strategies, which may be derived from quality STEAM education for the Filipinos.

As part of the strong foundation, the government emphasizes accelerating the Human Resource for highly-trusted and resilient society and globally-competitive knowledge economy. This segment of the development plan features strategies to achieve quality in all levels of education, which includes a broad stroke quality, accessible, relevant, and liberating basic education program for all, featuring teacher quality, and quality higher education and technical education accentuating Science, Technology and Innovation field. Thus, significant role is entrusted to the Philippine education, teacher quality and Philippine STEAM education for the government to realize the full potential of its workforce, contributory to the achievement of its intended visions.

PURPOSE

The attempt is to model the Philippine Higher STEAM Education and check how far are we from the global standards. Specifically, the study sought concrete retorts to the following objectives:

- **Develop the Philippine Higher STEAM Education Pedagogical Model**
- **Develop the Philippine Higher STEAM Education Assessment Model**
- **Develop the Philippine Higher STEAM Education Technology Integration Model**
- **Design and Develop the TPACK Model for Philippine Higher STEAM Education**
- **Design the Philippine STEAM Education Model**

THEORIES

In the development of the different frameworks to model the Philippine Higher STEAM education, significant contributions of the different theories, policies, and standards (e.g., Philippine Policies, Standards and Guidelines [PSGs], Philippine Professional Standards for Teachers [PPST], and Technological, Pedagogical Content Knowledge [TPACK]), contextualized the aforementioned Philippine Higher Education STEAM education model.

Policies, Standards, and Guidelines (PSG's)

Agencies, whether government-owned or privately-managed adhere to instituting documentary requirements such as policies, standards, and guidelines to ensure security of information within the organization while specifying operating and control details (Policies, Standards and Guidelines, 2009). Organizations typically have four types of documents in place:

POLICIES

Agencies consider this document as high-level documents signed by a person of significant authority (such as a corporate officer, president, or vice president, commissioner). This document generally states that a particular high-level control objective is important to the agency's success, which requires mandatory compliance.

STANDARDS

These mid-level documents ensure uniform application and implementation of a policy. Generally, compliance is mandatory, after securing approval. All standards are used as reference points to ensure organizational compliance and are regarded as norms to technical systems that support and help the policy.

GUIDELINES

This document intends to determine the course of action containing non-mandatory controls defined to support the standards. These are intended to provide advice pertaining to how organizational objectives might be obtained in the absence of a standard. Guidelines commonly are best practices that are strongly recommended and may contain additional recommendations that support and improve controls that are defined in a standard.

Accordingly, the Philippine Commission on Higher Education (CHED) adopted the Outcomes-based education (Biglete, 2018) to address the call for quality assurance in Philippine Higher Education (Commission on Higher Education Memorandum Order [CMO], No. 46, 2012). This effort consequently updated the Commission's policies, standards, and guidelines. Inclusive of such revisions are: 1) combination of minimum required general education subjects, core subjects, professional or major subjects including electives, 2) work or experiential learning as part of the curriculum, and 3) ranges of the minimum required total number of credit units for undergraduate programs. Additionally, almost all programs of the Commission required revision of their respective PSGs, which should include the following key elements:

A. Program Specifications

a. Program Description
   1. degree name
   2. nature of the field of study
   3. program goals
   4. specific professions/ careers/ occupations for graduates

b. Program Outcomes/Set of Learning
   1. Common to all programs in all types of schools
   2. Common to the discipline
   3. Specific to sub-discipline and a major
   4. Based on HEI's mission and vision

c. Sample Performance Indicators

B. Curriculum

a. Curriculum description
b. Sample curriculum
c. Sample curriculum map
d. Sample means of curriculum delivery
e. Sample syllabi for selected core courses

C. Minimum Required Resources

a. Administration
b. Faculty
c. Library Laboratory & Physical Facilities

Philippine Professional Standards for Teachers (PPST)

The Philippine Quality Framework (PQF, 2012) is a competency-based and labor-market driven national policy, that assures quality of development, recognition and award of qualifications based on standards of knowledge, skills and values acquired in different ways and methods by learners and workers of the country. The framework influences actions and strategies (spelt in PDP 2017-2022) to achieve globalization, internationalization, Industrial Revolution 4.0 (IR 4.0), and the country's economic growth through technological innovations, research and innovation, and the acceleration of human capital. These two national policies (PDP & PQF) illustrate qualities of the Philippine human capital, specifically extracting elaborations of these policies in teacher quality, which the Philippine Professional Standards of Teachers defines (PPST, 2017).

PPST (2017) outlines the needed competencies and skills of quality teachers to enable them to manage and handle emerging global frameworks. Specifically, PPST's aims include: "1) setting clear expectations of teachers along well-defined career stages of professional development from beginning to distinguished practice; 2) engaging teachers to actively embrace a continuing effort in attaining proficiency; and 3) applying a uniform measure to assess teacher performance, identify needs, and provide support for professional development" (DepEd adopts PPST, 2018).

This Philippine standard include seven (7) domains, which collectively comprise 37 strands that refer to more specific dimensions of teacher practices:

Domain 1, Content Knowledge and Pedagogy (with 7 strands):

- Content knowledge and its application within and across curriculum areas
- Research-based knowledge and principles of teaching and learning
- Positive use of ICT
- Strategies for promoting literacy and numeracy
- Strategies for developing critical and creative thinking, as well as other higher-order thinking skills
- Mother Tongue, Filipino and English in teaching and learning
- Classroom communication strategies

Domain 2, Learning Environment (with 6 strands):

- Learner safety and security
- Fair learning environment
- Management of classroom structure and activities
- Support for learner participation
- Promotion of purposive learning
- Management of learner behavior

Domain 3, Diversity of Learners (with 5 strands):

- Learners' gender, needs, strengths, interests and experiences
- Learners' linguistic, cultural, socio-economic and religious backgrounds
- Learners with disabilities, giftedness and talents
- Learners in difficult circumstances
- Learners from indigenous groups

Domain 4, Curriculum and Planning (with 5 strands):

- Planning and management of teaching and learning processes
- Learning outcomes aligned with learning competencies
- Relevance and responsiveness of learning programs
- Professional collaboration to enrich teaching practice
- Teaching and learning resources including ICT

Domain 5, Assessment and Reporting (with 5 strands):

- Design, selection, organization and utilization of assessment strategies
- Monitoring and evaluation of learner progress and achievement
- Feedback to improve learning
- Communication of learner needs, progress and achievement to key stakeholders
- Use of assessment data to enhance teaching and learning practices and programs

Domain 6, Community Linkages and Professional Engagement (with 4 strands):

- Establishment of learning environments that are responsive to community contexts
- Engagement of parents and the wider school community in the educative process
- Professional ethics
- School policies and procedures

Domain 7, Personal Growth and Professional Development (with 5 strands):

- Philosophy of teaching
- Dignity of teaching as a profession
- Professional links with colleagues
- Professional reflection and learning to improve practice
- Professional development goals

Technological, Pedagogical, Content Knowledge (TPACK)

This framework is heavily influenced by Shulman who acknowledged that merely understanding the subject matter is not sufficient to teach a subject. It is the teacher's PCK that makes quality and effective teaching (Karaman, 2012; Park & Oliver, 2007; Shulman, 1987). Researchers identified several factors that may influence teacher's PCK: 1) attendance to workshops and trainings (Clermont, Borko & Krajcick, 1994); 2) content knowledge (Aydin et al., 2009; Kaya, 2009; Usak, 2005; Villaluz, 2005); 3) knowledge of student conception and learning difficulties (Geddis, 1998; Van Driel et al., 1998); and 4) curriculum knowledge and knowledge on instructional strategies and assessment (Magnusson et al., 1999; Usak, 2005).

Guided by the dramatic technology revolution in the 21st century, Clark (2010) claimed that integrating technology in the curriculum and instruction will bring about significant student achievement leading to deep understanding of concepts. As defined by Clark (2010) "meaningful integration" of technology refers to the process of matching the most effective tool with the most appropriate pedagogy to achieve the learning goals of a particular lesson. A match on this desire are the goals of Mishra and Koehler (2006) of injecting technology on Shulman's (1986) concept of pedagogical content knowledge (PCK) to address the growing prominence of digital technologies in instructional settings. Geared towards tapping the transformative benefits and potentials of introducing technologies in instructional setting, Mishra and Koehler (2006) described the integration of technology into the teaching and learning system as Technological Pedagogical Content Knowledge (TPCK). Adhering to the belief that TPCK formed an integrated whole, the framework was later renamed as TPACK for Total PACKage (Thompson & Mishra, 2008). As a framework, TPACK focuses on the complex interactions between teacher's knowledge of the content (CK), pedagogy (PK), and technology (TK). Mishra and Koehler (2006) further claimed that a teacher who can navigate between these interrelations act as an expert who is different than a lone subject matter, pedagogy, or technology expert. With this framework, technology education has become an integral part of teacher education. In fact, assessing the effectiveness of technology education in the development of teachers' TPACK has been the trend in TPACK researches (Angeli & Valanides, 2009; Niess, 2008; Schmidt et al., 2009). Park, Jang, Chen and Jung (2011) even assessed teachers' level of TPACK using a rubric based on observations of teaching practices and pre/post observation interviews. PCK rubric was also developed by Gardner and GessNewsome (2011) using video tapes of teachers' classroom instructions, interviews and written reflections. Additionally, probable categories and profiling of STEAM educators through their TPACK competencies may provide better capacity building strategies as well.

This project envisions to design Quality Tertiary Education consequently aligned to the Philippine and Asian quality standards for quality assurance; and to the themes of *"AMBISYONNATIN 2040:" "Matatag, Maginhawa, at Panatag na Buhay* (Philippine Development Plan [PDP], 2017)." The country believed 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 pagunlad (increasing growth potential). These three priority areas emphasize among others promotion and awareness of Philippine culture, acceleration of human capital development, promotion of technology, and stimulation of innovation. Apparently, the make-up of the PDP framework puts STEAM as among the cores to achieving the 2040 goals. Thus, necessitates cross-cutting strategies, which may be derived from quality STEAM education Filipino learners.

This desire for quality STEAM Education is grounded on providing concrete, multi-faceted and interdisciplinary solutions to complex issues and problems the country usually face, brought about by man-made and natural factors. A well-thought of STEAM Education should include all facets of learning defined by the TPACK Framework which includes: Technology integration, innovative pedagogical approaches, appropriate assessment tools, and content standards and competencies. These existing frameworks may have reached the realms of the Philippine Higher Education, yet, concrete implementation of schemes to translate these framework to concrete outputs may be nil. Thus, this study focuses on developing an emerging TPACK Model for Philippine STEAM Education anchored on the TPACK Framework, PPST, and 45 PSGs, but customized to Philippine STEAM Education to identify the TPACK competencies of STEAM educators; identify the most innovative and appropriate pedagogical approaches for Filipino learners; to specify the useful assessment tools to formative development and assessment of learning; to model technology integration and identify content standards and competencies of STEAM Education unique to Filipino STEAM learners, but have global significance to bring them to better competitive stance. This study, thus, provides directions, pathways, and way forward in the field of STEAM education for better management of learning, development of quality STEAM human resources, STEAM literacy to enhance life management, resources management, risk reduction, and sustainability of knowledge and resources for quality living.

PROCEDURE

The generation of the different models and the emerging TPACK model for Philippine Higher STEAM Education highly depended on sourced data from online survey (extracted from 1455 STEAM educator respondents [national survey]), classroom observations and interviews of 106 participants determined through stratified and random sampling of state universities and privately-managed colleges and universities.

Coding (manual and software aided) directed the model (Pedagogical, Assessment, Technological Integration) generation. These models guided the decoding of all indicators of STEAM proficiency attributes and traits to the different TPACK dimensions (T, P, C, PC, TC, TP, TPC) from where the variables, dimensions, and indicators of the emerging TPACK model for Philippine Higher STEAM Education termed as "The Philippine STEAM Education Model" surfaced. Crafting of the different attributes per dimensions culminated the model generation process.

The Philippine STEAM Education Model (Validated)

The Philippine STEAM Education Model (validated)

The validated model for Philippine STEAM Education is anchored on the TPACK framework but customized to the Philippine STEAM Education. This model exemplifies innovative, appropriate, and contextualized **pedagogy**, **assessment**, and **technology integration** in educating the Filipino learners. Sourced from practicing STEAM teachers in the sampled HEIs (SUC levels 1 and 2, LUCs and non-autonomous private schools) in the entire archipelago with 2 stages of validation process, the model represents the current condition of STEAM teachers in the identified HEI clusters. It is envisioned that the model captures the exact conditions of the STEAM teachers in the identified clusters of HEIs and could provide and enhance the teaching competencies of STEAM Educators for them to fluidly traverse the career stages (Beginner, Proficient, Highly Proficient, Distinguished) looking forward to attaining quality in Philippine STEAM Education to develop and craft Generation Z learners with specialized skills (e.g., design thinking, technical know how, and time management) in preparation for these citizens to be part of Workforce 4.0. Additionally, the model (as visualized in Figure 1) affords directions, pathways, and way forward in the field of STEAM education in these HEI clusters for better management of learning to develop quality STEAM human resources as outcomes, and enhances STEAM literacy to improve life management, resources management, risk reduction and sustainability of knowledge and resources to develop lifelong learning skills for quality living.

The model in ***Figure 1*** shows a wheel-like image emphasizing the three teaching and learning domains (pedagogy, assessment, and technology integration) situated in the outermost part of the wheel which emphasize the convolution (entanglement) of the three domains to influence STEAM education.

As a visual fruition of the weaving nature of the three teaching and learning domains, four major variables surfaced as common to the domains: outcomes (represented as innovative STEAM learner or professional, critical thinker, productive citizen), drivers, institutional support, and processes. The circular nature of the model emphasizes balance and equality between and among the variables. The color scheme accentuates the lead institution's and the funding agency's branding underscoring blue (darker shade of the innermost image) to mean intellect and freshness, which represents the outcomes (represented as innovative STEAM learner or professional, critical thinker, productive citizen), as one of the major variables of the model. Radiating outward are the three other variables with their corresponding dimensions colored in dark blue (for the institutional support) to emphasize knowledge, power and integrity; green (for drivers) to showcase harmony of dimensions and variables as well; and brown (for processes) that signifies being down to earth, sustained for stability, and being supported with good structure. Dimensions in the process variable are represented by yellow color that exhibits intellect, energy, warming effect, stability, and spontaneity. We chose this color (yellow) to represent the process variable, which we believe exemplifies the TPACK framework generating the seven dimensions that represent the seven-knowledge system a STEAM educator should develop to marvel upon the intricacies and uniqueness of STEAM teaching and learning. The color (yellow) signifies the childlike nature of the variable (as yellow is often used as the colors of toys) modelling a playroom-like environment that focuses on the learning and the learners (Color Theory in Action, 2015). The uneven number of variables fitting in the stable stance of the three variables, represent equity in the teaching and learning domains. Since we sourced all data from less performing HEIs (SUCs levels 1 and 2, LUCs, non-autonomous private institutions) in the country offering STEAM programs, we note that though we always go for quality, we also consider and also emphasize the concept of equity issues in the three variables: institutional support, drivers and processes.

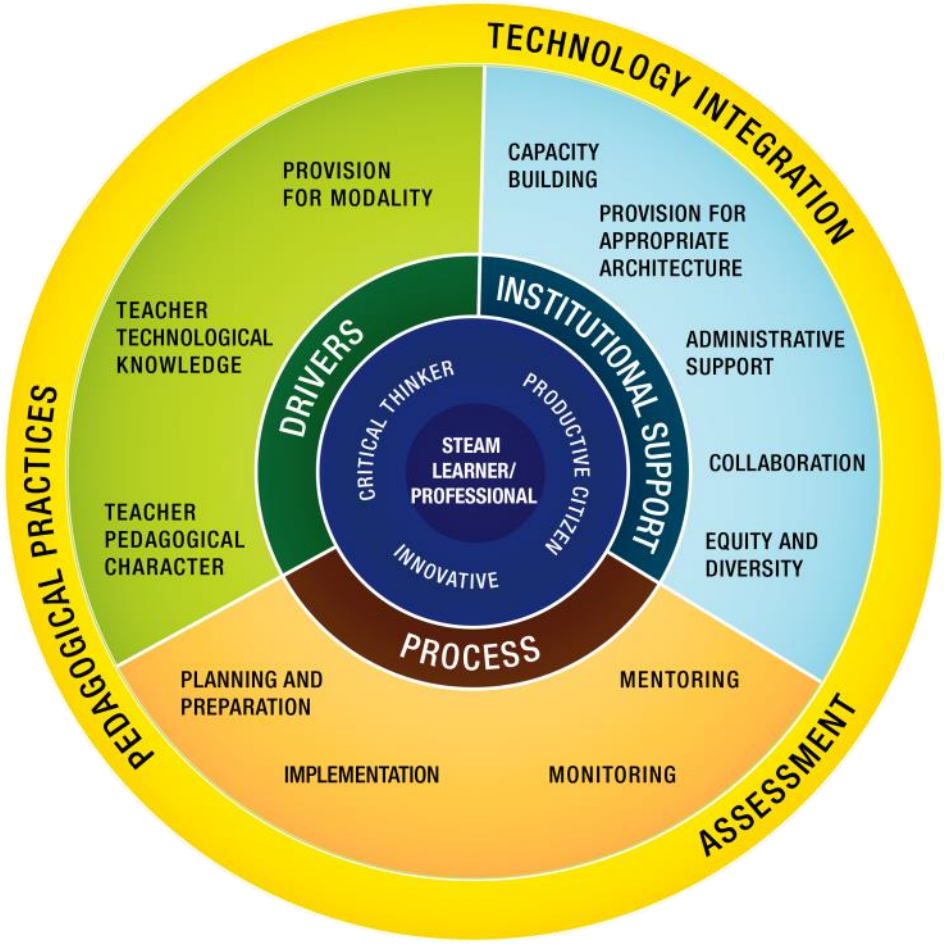

Figure 1. The Philippine STEAM Education (PSE) Model (Validated)

Variables of the Model

The Philippine STEAM Education model adopts the definition of variable as a characteristic or quality, magnitude or quantity, that can undertake transformations and that is subject to analysis, measurement, assessment, or control during a research endeavor (Arias, 2012; Wright & Lake, n.d.). In STEAM Education, we define a variable as a characteristic that expresses the feature or parameter (that is, a parameter is an element of a system that is useful, or critical, when identifying the system, or when evaluating its performance, status, condition, etc.) of the practices of STEAM educators in terms of the three domains of teaching and learning: Pedagogy, Assessment, and Technology Integration. There are four variables reflected in the integrative model developed for Philippine STEAM education: outcomes, drivers, institutional support and the processes.

Outcomes

This variable appears as the core of the Philippine STEAM Education model. Generally, outcomes are what are expected as the result of a program or a project. These are very specific statements or phrases that describe exactly what a learner will be able to do in a measurable way (Gosselin, 2017). In the context of the philosophy of Outcomes-based Education (OBE) that the country advocates, higher and advanced learning in all disciplines refer to outcomes as what the schools are expected to achieve.

Drawn from the model analysis of the three domains, we define the outcomes of the Philippine STEAM Education sourced from the major STEAM pedagogical processes that includes STEAM human resource who: a) exhibit critical thinking skills, b) are successful in licensing, and c) are employable.

Drivers

The second variable refers to the Drivers of Philippine STEAM Education, which detail the key factors and main considerations of STEAM education in the country. They include knowledge, conditions, or set of characteristics of people that initiate and support the activities for which Philippine STEAM education is designed.

Institutional Support

This variable is vital, as it refers to the capabilities, forces, and resources that contributes to the success of the Philippine STEAM Education processes. The variable traces the support of the institution to STEAM Education processes which includes affordance and affordability, appropriateness and appropriations, availability, and sustainability.

Processes

Our last variable refers to the mechanisms and progressions of STEAM educators' STEAM education practices covering the three education domains(major spheres or activities of teaching and learning process): pedagogy, assessment and technology integration. The process variable involves a wide spectrum that covers plan of action, course and line of action, drills, practices and strategies with reflective means to sustainable operation of processes of educating STEAM learners.

Dimensions of the Model

Each variable covers several dimensions that enumerate the scope of the variable in terms of Philippine STEAM education. The dimensions as described in this model frame the route of the actions and cover the distinctive feature of the whole, as an integrated piece (Butter, Aguilera, Quintana, Pérez, & Valenzuela, 2017). Specifically, a dimension of a variable seizes a single aspect of STEAM education. Sourced from the three education domains, we identified common dimensions from the domains to match the intentions and roles of each of the aforementioned variables. Coded responses from the Philippine STEAM educators supplied the major indicators sourced from the three domains and clustered in the different dimensions of the model, and then labeled as per TPACK framework. In this model, we define "Indicators" as a set of features or characteristics that allow or establish the description and evaluation of certain dimensions of a variable. They usually come in varied ways like a checklist that enables the measurement of the achieved degree of quality or as guiding questions. Figure 2 shows the detailed map of the variables, the dimensions in each variable with the different corresponding indicators labeled as per TPACK framework knowledge constructs. We used mind mapping technique to represent all enumerated specifics and connections of variables and construct relations of the model's variables, dimensions, and indicators. We also used colors to code the indicators in the corresponding knowledge in TPACK framework.

The Philippine STEAM Education Model (Emerging)

The Philippine STEAM Education Model (emerging)

The emerging model for Philippine STEAM Education is anchored on the TPACK framework but customized to the Philippine STEAM Education. This model exemplifies innovative, appropriate, and contextualized **pedagogy**, **assessment**, and **technology integration** in educating the Filipino learners to become productive citizens, innovative STEAM professionals, and 21st century-skilled human resource. Sourced from practicing STEAM teachers in the sampled HEIs (SUC levels 1 and 2, LUCs and non-autonomous private schools) in the entire archipelago, and from the inputs of exemplar STEAM educators from Philippine HEIs tagged as Centers of Excellence (COE) and Centers of Development (COD), the emerging model visualizes the Philippine STEAM Education that will be able to produce outcomes (productive citizens, innovative STEAM professionals, and 21st century-skilled human resource) to improve the country's STEAM condition and enhance its global and international metrics as well. It is envisioned that the model captures the exact conditions of the STEAM teachers in HEIs, and at the same time provides and enhances the teaching competencies of STEAM Educators for them to fluidly traverse the career stages (Beginner, Proficient, Highly Proficient, Distinguished) looking forward to attaining quality in Philippine STEAM Education to develop and craft Generation Z learners with specialized skills (e.g., design thinking, technical know-how, and time management) in preparation for these citizens to be part of Workforce 4.0. Additionally, the model (as visualized in Figure 1) affords directions, pathways, and way forward in the field of STEAM education for better management of learning to develop quality STEAM human resources as outcomes, and enhances STEAM literacy to improve life management, resources management, risk reduction and sustainability of knowledge and resources to develop lifelong learning skills for quality living.

The model in ***Figure 2*** shows a wheel-like image emphasizing the three teaching and learning domains (*pedagogy, assessment, and technology integration*) situated in the outermost part of the wheel, which emphasize the convolution (entanglement) of the three domains to influence STEAM education.

As a visual fruition of the weaving nature of the three teaching and learning domains, four major variables surfaced as common to the domains: outcomes (*represented as innovative STEAM learner or professional, 21st century-skilled human resource, productive citizen*), drivers, institutional support, and processes. The circular nature of the model emphasizes balance and equality between and among the variables. The color scheme accentuates the lead institution's and the funding agency's branding underscoring blue (dark shade of the innermost image) to mean intellect and freshness, which represents the outcomes (*represented as innovative STEAM learner or professional, 21st century-skilled human resource, productive citizen*), as one of the major variables of the model. The inward orientation of the model depicts the concerted efforts of the variables (*drivers, pedagogical practices, and institutional support*) and the dimensions in each variable in attaining the envisioned outcomes. We used colors to accentuate the meanings. The three other variables with their corresponding dimensions are colored in dark blue (for the institutional support) to emphasize knowledge, power and integrity; green (for drivers) to showcase harmony of dimensions and variables as well; and brown (for processes) to signify being down to earth, sustained for stability, and being supported with good structure. Dimensions in the process variable are represented by yellow color that exhibits intellect, energy, warming effect, stability, and spontaneity. We chose this color (yellow) to represent the process variable, which we believe exemplifies the TPACK framework generating the seven dimensions that represent the seven-knowledge system a STEAM educator should develop to marvel upon the intricacies and uniqueness of STEAM teaching and learning. The color (yellow) signifies the childlike nature of the variable (as yellow is often used as the colors of toys) modelling a playroom-like environment that focuses on the learning and the learners (Color Theory in Action, 2015). The uneven number of variables fitting in the stable stance of the three variables, represent equity in the teaching and learning domains. Since we sourced all data from less performing HEIs (SUCs levels 1 and 2, LUCs, non-autonomous private institutions), and from the inputs of of exemplar STEAM educators from Philippine HEIs tagged as Centers of Excellence (COE) and Centers of Development (COD) in the country offering STEAM programs, we note that though we always go for quality, we also consider and also emphasize the concept of equity issues in the three variables: ***institutional support, drivers and processes.***

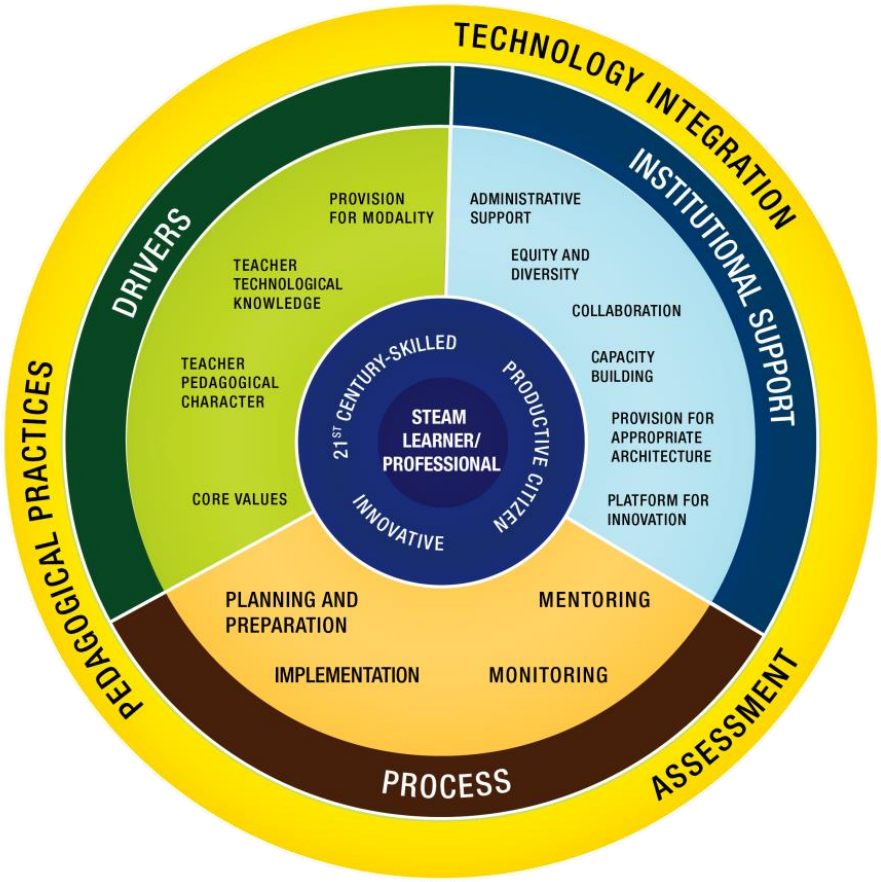

Figure 2. The Philippine STEAM Education (PSE) Model (Emerging)

Variables of the Model

The Philippine STEAM Education model adopts the definition of variable as a characteristic or quality, magnitude or quantity, that can undertake transformations and that is subject to analysis, measurement, assessment, or control during a research endeavor (Arias, 2012; Wright & Lake, n.d.). In STEAM Education, we define a variable as a characteristic that expresses the feature or parameter (that is, a parameter is an element of a system that is useful, or critical, when identifying the system, or when evaluating its performance, status, condition, etc.) of the practices of STEAM educators in terms of the three domains of teaching and learning (Pedagogy, Assessment, and Technology Integration). There are four variables reflected in the "emerging" integrative model developed for Philippine STEAM education: (outcomes, drivers, institutional support, and processes). Each variable covers several dimensions that enumerate the scope of the variable in terms of Philippine STEAM education. The dimensions as described in this model frame the route of the actions, and cover the distinctive feature of the whole, as an integrated piece (Butter, Aguilera, Quintana, Pérez, & Valenzuela, 2017). Specifically, a dimension of a variable seizes a single aspect of STEAM model. Sourced from the three education domains, we identified common dimensions from the domains to match the intentions and roles of each of the aforementioned variables.

Outcomes

This variable appears as the core of the Philippine STEAM Education model. Generally, outcomes are what are expected as the result of a program or a project. These are very specific statements or phrases that exactly describe what a learner will be able to do in a measurable way (Gosselin, n.d.). In the context of the philosophy of Outcomes-based Education (OBE) that the country advocates, higher and advanced learning in all disciplines refer to outcomes as what the schools are expected to achieve.

Drawn from the model analysis of the three domains, we define the outcomes of the Philippine STEAM Education sourced from the major STEAM pedagogical processes that includes STEAM human resource who are: a) 21st century-skilled human resource, b) innovative STEAM professional/learner, and c) productive citizens (members of the society).

Drivers

The second variable refers to the Drivers of Philippine STEAM Education (teacher technological knowledge, teacher pedagogical character, provision for modality, and core values), which detail the key factors and main considerations of STEAM education in the country. They include knowledge, conditions, or set of characteristics of people that initiate and support the activities for which Philippine STEAM education is designed. Specifically, the teacher technological knowledge refers how STEAM educators understand technology. Their knowledge of technology goes from familiarity with various technology through understanding how to make and use specific technology to identified lessons, and assessing when technology assists or impedes lesson delivery. Teacher pedagogical character features the STEAM educators' epistemological beliefs and pedagogical practices. Provision for modality as one of the drivers, envisions STEAM education as flexible in delivering all STEAM disciplines. Finally, core values highlight institution-based or directed individual value systems that are deemed necessary for institutions to determine if they are on the right path in fulfilling their vision, mission and goals as anchored to the desired STEAM outcomes.

Institutional Support

This variable is vital, as it refers to the capabilities, forces, and resources that contribute to the success of the Philippine STEAM Education processes. The variable traces the support of the institution to STEAM Education processes, which includes administrative support, equity and diversity, collaboration, capacity building, provision for appropriate architecture, and platform for innovation. Specifically, administrative support dwell on infrastructure, program and manpower management, finance and other administrative concerns. Collaboration captures the entirety of institution-initiated and supported collaborations, which includes research collaboration between and among institutions and instructional and research collaboration among faculty and staff within and among institutions. Finally, platform for innovation covers all aspects of STEAM education (i.e., products, processes, services, technologies).

Processes

Our last variable refers to the mechanisms and progressions of STEAM teachers' STEAM education practices covering the three education domains: pedagogy, assessment and technology integration. The process variable (planning and preparation, implementation, monitoring, mentoring) involves a wide spectrum that covers plan of action, course and line of action, drills, practices and strategies with reflective means to sustainable operation of processes of educating STEAM learners.

Variables and Dimensions of the Model

Coded responses from Philippine STEAM educators supplied the major indicators sourced from the three domains and clustered in the different dimensions of the model, and then labeled as per TPACK framework. In this model, we define "Indicators" as a set of features or characteristics that allow or establish the description and evaluation of certain dimensions of a variable. They usually come in varied ways like a checklist that enables the measurement of the achieved degree of quality or as guiding questions. Figure 3 shows the detailed map of the variables, the dimensions in each variable with the different corresponding indicators labeled according to the as per TPACK framework knowledge constructs. We used mind mapping technique to represent all enumerated specifics and connections of variables and construct relations of the model's variables, dimensions and indicators. We also used colors to code the indicators in the corresponding knowledge in TPACK framework.

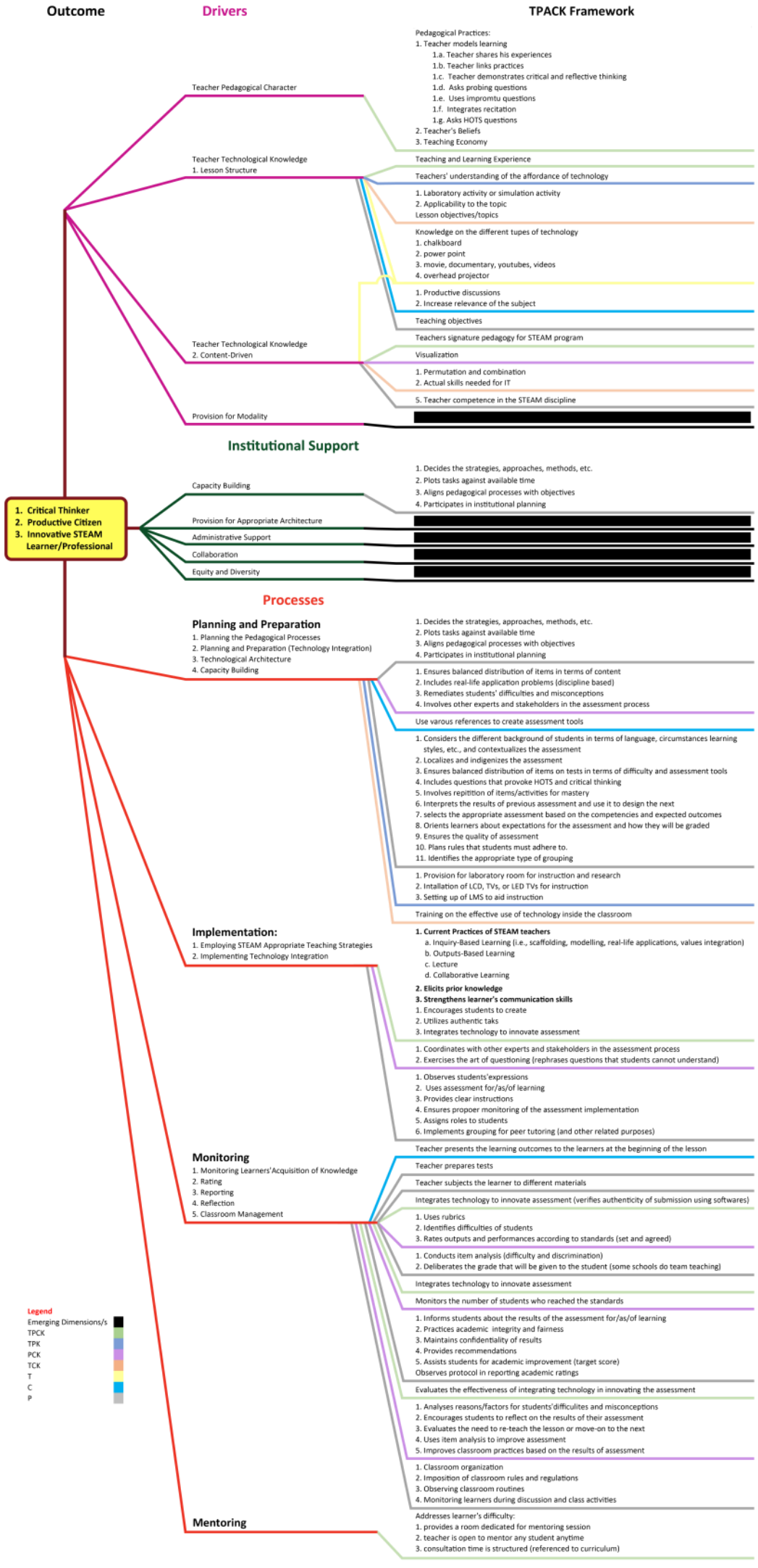

Figure 3. TPACK-influenced mapped Indicators and Dimensions of the Philippine STEAM Education Model (Validated)

Figure 3. TPACK-influenced mapped Indicators and Dimensions of the Philippine STEAM Education Model (Validated)

Outcomes enumerate the least number of dimensions that spell out the products of Philippine STEAM Education: critical thinker/21st-century-skilled (for emerging), productive citizen, and innovative STEAM leaner/professional. As per the Model (Figure 2), these are the outcomes of the integrated efforts of the remaining variables. Drivers comprise four dimensions with indicators coded as per the knowledge developed in the TPACK framework. Among the four knowledge constructs, 1) TPCK (Technological Pedagogical Content Knowledge, 2) and TCK (Technological Content Knowledge, register the most number of indicators of the "Drivers." Similarly, the "Institutional Support" variable only covers five dimensions, but most indicators point to PK (Pedagogical Knowledge). The most represented "Process" variable registers the greatest number of dimensions and indicators per dimension. However, the map (Figure 3) shows that though this variable comprise a handful of indicators (as sourced from STEAM educators in the field), TPCK (5) and PCK (4) are only next to "Pedagogical Knowledge (8)," which dominates the entire "Process" variable.

Apparently, the model (with the map in Figure 2) exemplify the current STEAM education in the Philippines and the educators' STEAM education proficiency (which may be quantified using the developed tool: Proficiency Indicators for Philippine STEAM Education with the Scoring Framework [Appendix A]) as described using the TPACK framework. The tagged TPACK dimension as exhibited by the indicators in each of the variables and dimensions of the variables present a linear progression of STEAM education proficiency of educators. As per our sourced data through intensive classroom observations and interviews, our STEAM educators try to singly develop one knowledge construct of the TPACK framework at a time. More often than not, we observe the sequence of development as content, pedagogy, and technology. This might be the case since, STEAM educators are profiled as discipline-specific higher and advanced learning educators, in which they focus on singular knowledge of the TPACK framework before being able to take a step further to blending the knowledge in the TPACK framework until they eventually attain a status in which they possess an understanding of: 1) how technology applies represent the concepts of the discipline; 2) how to effectively use technology in pedagogical techniques; and 3) how technologies can address the difficulties students face when learning the concepts. All such aforementioned attributes mark the success of TPACK in STEAM education, which is currently a blur situation in Philippine STEAM education. Efforts may be emphasized in upskilling and capacity building to help our STEAM educators blend and weave TPACK knowledge and easily traverse the Philippine STEAM Educator career stages until they reach the highest identified career stage with attributes provided in Table 1 and the required documents for verification per career stages in the succeeding Tables.

Table 1. Attributes and Career Stages

	Career Stage 1 Beginner/Novice (They have acquired the skill)	Career Stage 2 Proficient/Developing (They are applying the skills)	Career Stage 3 Highly Proficient/Competent (They collaborate to improve their application of skills)	Career Stage 4 Distinguished/Expert (They try to mentor and establish policies)
General Attributes of STEAM Educator	Beginning/Novice STEAM Educators have gained the basic qualifications recognized for entry into the Philippine Higher STEAM Education.	Proficient STEAM Educators are professionally reliant on the applications of skills vital for them to employ knowledge of STEAM disciplines, language and communication within and across curriculum to support student learning, understanding, participation, engagement and achievement in different STEAM learning contexts.	Highly Proficient STEAM Educators collaborate, share or disseminate knowledge and transfer technology to unfailingly exhibit a high level of competence in their STEAM education practice grounded on local and national perspectives, and research-based undertakings, anchored on globally-acclaimed best and finest suitable practices and principles.	Distinguished STEAM Educators mentor colleagues and initiate policy inputs to exemplify the highest standard for STEAM education grounded on local and national perspectives, and research-based undertakings, anchored on globally-acclaimed best and finest suitable practices and principles.
Knowledge of STEAM Discipline	They have a strong understanding of the STEAM discipline in which they are trained in terms of content knowledge, pedagogy, and integration of technology.	They provide and apply focused STEAM teaching programs that meet curriculum and assessment requirements.	They collaborate to share and disseminate effective application of STEAM discipline, research, language, and communication, within and across curricula to promote STEAM literacy and to develop Filipino learners' critical and creative thinking, and higher-order thinking skills responsive to national and global goals.	Their exceptional capacity to acquire knowledge and exemplar practice to improve knowledge on STEAM disciplines and in the fields of research, languages and communication utilizing STEAM meta-discipline to develop Filipino learners' STEAM skills (e.g., design thinking skills, time management, technical know-how, and cognitive and emotional intelligences) responsive to national and global goals is shown in their ability to train others in acquiring a strong understanding of the discipline.

Table 1. Attributes and Career Stages

	Career Stage 1 Beginner/Novice (They have acquired the skill)	Career Stage 2 Proficient/Developing (They are applying the skills)	Career Stage 3 Highly Proficient/Competent (They collaborate to improve their application of skills)	Career Stage 4 Distinguished/Expert (They try to mentor and establish policies)
Research-based knowledge of STEAM disciplines	They demonstrate possession of research-based knowledge of STEAM discipline, its related fields (research, language and communication and STEAM-related laboratory/clinical skills), and principles of teaching and learning to enhance their professional practice.	They utilize research-based knowledge of STEAM disciplines its related fields (research, language and communication and STEAM-related laboratory/clinical skills), and principles of teaching and learning to enhance their professional practice.	They manifest an in-depth and sophisticated understanding STEAM research and collaborate for the conduct and application of STEAM research to promote the welfare of STEAM profession in schools and the community as well.	They exemplify knowledge generation, dissemination, and knowledge sustainability for professional practice, community service to promote the welfare of STEAM profession in schools and the community as well.
Knowledge, Skills and Values for STEAM teaching and learning processes	They possess the requisite knowledge, skills and values that support the STEAM teaching and learning process. They show possession of knowledge of teaching strategies and they manifest capacity to manage learning programs that promote learning based on the learning needs of the students.	They display skills in planning, implementing and managing learning programs and curricula within the STEAM classroom. They 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 growth and advancement.	They exhibit support to STEAM education by contributing to the STEAM profession as collaborators and participants in projects and programs aimed to forge productive and innovative products, programs and curricula through local and international partnerships. They work together 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 professionals, colleagues, diverse learners/students and the community.	They are recognized as groundbreakers in STEAM education, contributors to the STEAM profession and initiators of collaborations that can forge productive and innovative products, programs and curricula through local and international partnerships. They 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 professionals, colleagues, diverse learners/students and the community.

Table 1. Attributes and Career Stages

	Career Stage 1 Beginner/Novice (They have acquired the skill)	Career Stage 2 Proficient/Developing (They are applying the skills)	Career Stage 3 Highly Proficient/Competent (They collaborate to improve their application of skills)	Career Stage 4 Distinguished/Expert (They try to mentor and establish policies)
Assessment, Monitoring Learning and Feedback System	They possess knowledge of the use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement.	They exhibit effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement. They manifest capability of using assessment data to address challenges in implementing effective teaching and learning practices	They participate and cooperate in a collective, complete, and sensible planning, selecting, implementing and monitoring assessment and evaluation of student learning, feedback system and designing of assessment-based programs and plan of actions for better progress in student learning.	They model, exemplify, and mentor planning, selecting, implementing and monitoring assessment and evaluation of student learning, feedback system and designing of assessment-based programs and plan of actions for better progress in student learning.
Professional Development and Personal Growth	They seek professional growth through attendance to conferences, fora, seminars, and workshop to gain knowledge on content and teaching the STEAM discipline from STEAM professionals experienced colleagues to improve their practice.	They seek professional growth through presentation of research outputs to conferences, fora, seminars, and workshop to disseminate knowledge and gain knowledge as well on STEAM discipline and on content and teaching the STEAM discipline from STEAM professionals experienced colleagues to improve their practice.	They continually aspire to improve their professional and personal growth through knowledge creation, and dissemination, and collaboration with experienced colleagues and STEAM experts and professionals on discipline and on content and teaching the STEAM discipline	They sustainably advance and pursue excellence in STEAM quality teaching and research and commits to inspire the education community and stakeholders for the improvement of education provision in the Philippines.

Table 2. Required Documents for Verification (Beginner)

	Career Stage 1 Beginner/Novice	Required Documents for Verification
General Attributes of STEAM Educator	Beginning/Novice STEAM Educators have gained the basic qualifications recognized for entry into the Philippine Higher STEAM Education.	• Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (Undergraduate degree program) • Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (for Graduate degree-Masters) • Program or Discipline-based required standard (e.g., licensing, certification) • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Others (please specify and provide annotations)
Knowledge of STEAM Discipline	They have a strong understanding of the STEAM discipline in which they are trained in terms of content knowledge, pedagogy, and integration of technology.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus highlighting strong understanding of the STEAM discipline through knowledge of the discipline, pedagogy, and technology integration. • Instructional materials and teaching tools used in the demonstration teaching highlighting possession of strong understanding of the discipline • Copy of the assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester. • Results of the assessment and performance highlighting understanding of the lesson by the STEAM learners. • Copy of student evaluation • Others (please specify and provide annotations)

Table 2. Required Documents for Verification (Beginner)

	Career Stage 1 Beginner/Novice	Required Documents for Verification
Research-based knowledge of STEAM disciplines	They demonstrate possession of research-based knowledge of STEAM discipline, its related fields (research, language and communication and STEAM-related laboratory/clinical skills), and principles of teaching and learning to enhance their professional practice.	• Program or Discipline-based required standard (e.g., licensing, certification) related to research. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Certificates of Participation or Attendance to Seminars, fora, trainings, workshops. • Others (please specify and provide annotations)
Knowledge, Skills and Values for STEAM teaching and learning processes	They possess the requisite knowledge, skills and values that support the STEAM teaching and learning process. They show possession of knowledge of teaching strategies and they manifest capacity to manage learning programs that promote learning based on the learning needs of the students.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus highlighting strong understanding of the STEAM discipline through knowledge of the discipline, pedagogy, and technology integration. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Copy of Certificate of attendance/participation to seminars and trainings on teaching strategies i STEAM fields, assessment, technology integration. • Others (please specify and provide annotations)

Table 2. Required Documents for Verification (Beginner)

	Career Stage 1 Beginner/Novice	Required Documents for Verification
Assessment, Monitoring Learning and Feedback System	They possess knowledge of the use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement. They manifest capability of using assessment data to address challenges in implementing effective teaching and learning practices	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus highlighting strong understanding of the STEAM discipline through knowledge of the discipline, pedagogy, and technology integration. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Copy of Certificate of attendance/participation to seminars and trainings on teaching strategies in STEAM fields, assessment • Copy of the assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester • Results of the assessment and performance highlighting understanding of the lesson by the STEAM learners. • Others (please specify and provide annotations)
Professional Development and Personal Growth	They seek professional growth through attendance to conferences, fora, seminars, and workshop to gain knowledge on content and teaching the STEAM discipline from STEAM professionals experienced colleagues to improve their practice.	• Certificates of Participation or Attendance to Seminars, fora, trainings, workshops. • Copy of their session guide and syllabus highlighting strong understanding of the STEAM discipline through knowledge of the discipline, pedagogy, and technology integration. • Others (please specify and provide annotations)

Table 3. Required Documents for Verification (Proficient)

	Career Stage 2 Proficient/Developing	Required Documents for Verification
General Attributes of STEAM Educator	Proficient STEAM Educators are professionally reliant on the applications of skills vital for them to employ knowledge of STEAM disciplines, language and communication within and across curriculum to support student learning, understanding, participation, engagement and achievement in different STEAM learning contexts.	• Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (Undergraduate degree program) • Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (for Graduate degree-Masters) • Transcript of Record or certification of Units taken in a STEAM doctoral program • School-based merit system or promotion system (for private HEIs and LUCs) document of proficiency as a tertiary educator or Rating **(for Assistant Professor level) based on Faculty Ranking and Promotion of NBC 461 (for SUCs)** • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Membership to Professional Organizations • Student Evaluation • Others (please specify and provide annotations)
Knowledge of STEAM Discipline	They provide focused STEAM teaching programs that meet curriculum and assessment requirements.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the faculty's ability to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Instructional materials, specific discipline-based technology, and teaching tools used in the demonstration teaching highlighting command of his/her STEAM discipline in the teaching and learning process of STEAM learners. • Copy of the assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester. • Results of the assessment and performance highlighting an **in-depth** understanding of the lesson by the STEAM learners. • Copy of student evaluation • Others (please specify and provide annotations)

Table 3. Required Documents for Verification (Proficient)

	Career Stage 2 Proficient/Developing	Required Documents for Verification
Research-based knowledge of STEAM disciplines	Proficient STEAM Educators are professionally reliant on the applications of skills vital for them to employ knowledge of STEAM disciplines, language and communication within and across curriculum to support student learning, understanding, participation, engagement and achievement in different STEAM learning contexts.	• Program or Discipline-based required standard related to research (copy of research proposal, completed research, publication). • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Certificates for Presentation of Research in national, regional or international research fora • Membership to research organizations. • Certificate of attendance and participation to Research and Publication Capability Building Programs • Copy of published book or instructional materials • Others (please specify and provide annotations)
Knowledge, Skills and Values for STEAM teaching and learning processes	They display skills in planning, implementing and managing learning programs and curricula within the STEAM classroom. They 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 growth and advancement.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the faculty's ability to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Minutes of Meeting stipulating attendance and participation to Department-level and/or College-level, curricular workshops. • Memorandum stipulating that STEAM educator is a member of curricular or curriculum committee. • Certification by the head of the department or college dean for collaborative team teaching. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Copy of Certificate of attendance/participation to seminars and trainings on teaching strategies in STEAM fields, assessment, technology integration. • Others (please specify and provide annotations)

Table 3. Required Documents for Verification (Proficient)

	Career Stage 2 Proficient/Developing	Required Documents for Verification
Assessment, Monitoring Learning and Feedback System	They exhibit effective use of assessment strategies, monitoring and evaluation, and feedback system consistent with the curriculum requirement. They manifest capability of using assessment data to address challenges in implementing effective teaching and learning practices	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the faculty's ability to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Copy of Certificate of attendance/participation to seminars and trainings on teaching strategies in STEAM fields, assessment, monitoring and evaluation of student learning. • Copy of the assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester • Results of the assessment and performance highlighting understanding of the lesson by the STEAM learners. • Minutes of Meeting stipulating attendance and participation to Department-level, College-level, Institution-level discussion on assessment results for instructional planning • Others (please specify and provide annotations)
Professional Development and Personal Growth	They seek professional growth through presentation of research outputs to conferences, fora, seminars, and workshop to disseminate knowledge and gain knowledge as well on STEAM discipline and on content and teaching the STEAM discipline from STEAM professionals experienced colleagues to improve their practice.	• Certificates of Participation or Attendance to Seminars, fora, trainings, workshops. • Certificates for Presentation of Research in national, regional or international research fora • Membership to research organizations. • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the faculty's ability to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Others (please specify and provide annotations)

Table 4. Required Documents for Verification (Highly Proficient)

	Career Stage 2 Highly Proficient/Competent	Required Documents for Verification
General Attributes of STEAM Educator	Highly Proficient STEAM Educators collaborate, share or disseminate knowledge and transfer technology to unfailingly exhibit a high level of competence in their STEAM education practice grounded on local and national perspectives, and research-based undertakings, anchored on globally-acclaimed best and finest suitable practices and principles.	• Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (Undergraduate degree program) • Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (for Graduate degree-Masters) • Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (for Graduate degree-Doctorate Degree) • School-based merit system or promotion system (for private HEIs and LUCs) document of proficiency as a tertiary educator or Rating **(for Associate Professor level) based on Faculty Ranking and Promotion of NBC 461 (for SUCs)** • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Active Membership (e.g., joins committee, holds a position in the board) to Professional Organizations • Invited as resource speaker in teaching the STEAM discipline or in the discipline • Author of textbooks or published instructional materials, and research publications (*CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals)* • With a number of research citations (h-index[google scholar] of at least 3 • Certificate of significant contribution to the community • Student Evaluation • Others (please specify and provide annotations)

Table 4. Required Documents for Verification (Highly Proficient)

	Career Stage 2 Highly Proficient/Competent	Required Documents for Verification
Knowledge of STEAM Discipline	They collaborate to share and disseminate effective application of STEAM discipline, research, language, and communication, within and across curricula to promote STEAM literacy and to develop Filipino learners' critical and creative thinking, and higher-order thinking skills responsive to national and global goals.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the use of STEAM as a meta-discipline and the faculty's ability to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Certificate or minutes of meeting or workshop stipulating facilitation and participation in collaborative development of instructional materials, specific discipline -based technology, and teaching tools in teaching and learning of the STEAM discipline of STEAM learners. • Certificate or minutes of meeting or workshop stipulating facilitation and participation in the collaborative development of assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester. • Results of the assessment and performance highlighting an **in-depth** understanding of the lesson by the STEAM learners and **acquisition of 21st century skills** such as design thinking, critical thinking, and innovativeness. • Certificate of Appreciation or Recognition as resource speaker in teaching the STEAM discipline or in the STEAM discipline • Author of textbooks or published instructional materials, and research publications • Copy of student evaluation • Others (please specify and provide annotations)

Table 4. Required Documents for Verification (Highly Proficient)

	Career Stage 2 Highly Proficient/Competent	Required Documents for Verification
Research-based knowledge of STEAM disciplines	They manifest an in-depth and sophisticated understanding STEAM research and collaborate for the conduct and application of STEAM research to promote the welfare of STEAM profession in schools and the community as well.	• Program or Discipline-based required standard related to research (*copy of research proposal of a locally-funded research, completed research, publication in CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals*). • Collaborative work on developing utility models for STEAM • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Certificates for Presentation of Research in national, regional or international research fora (Scopus-indexed and ISI-indexed fora) • Active Membership (e.g., joins committee, holds a position in the board) to Professional Organizations • Certificate of Appreciation or Recognition as resource speaker in teaching the STEAM discipline or in the STEAM discipline • Certificate of Appreciation or Recognition as resource speaker in Research and Publication Capability Building Programs • Certificate of mentorship of undergraduate graduate students (masters program) • Copy of published book or instructional materials • Certificate of significant contribution to the community • Others (please specify and provide annotations)

Table 4. Required Documents for Verification (Highly Proficient)

	Career Stage 2 Highly Proficient/Competent	Required Documents for Verification
Knowledge, Skills and Values for STEAM teaching and learning processes	They exhibit support to STEAM education by contributing to the STEAM profession as collaborators and participants in projects and programs aimed to forge productive and innovative products, programs and curricula through local and international partnerships. They work together 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 professionals, colleagues, diverse learners/students and the community.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the use of STEAM as a meta-discipline, and the faculty's ability to use the findings and products of STEAM research to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Minutes of Meeting stipulating facilitation of curricular workshops in College or Department level and/or attendance and participation to Institution-level curricular workshops. • Memorandum stipulating that STEAM educator is a member of curricular or curriculum committee (institutional-level). • Certification by the head of the department or college dean that the STEAM faculty **facilitated** collaborative team teaching. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Certificate of Appreciation or Recognition as resource speaker in teaching the STEAM discipline or in the STEAM discipline • Others (please specify and provide annotations)

Table 4. Required Documents for Verification (Highly Proficient)

	Career Stage 2 Highly Proficient/Competent	Required Documents for Verification
Assessment, Monitoring Learning and Feedback System	They participate and cooperate in a collective, complete, and sensible planning, selecting, implementing and monitoring assessment and evaluation of student learning, feedback system and designing of assessment-based programs and plan of actions for better progress in student learning.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the use of STEAM as a meta-discipline, and the faculty's ability to use the findings and products of STEAM research to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Copy of Certificate of attendance/participation to seminars and trainings on teaching strategies in STEAM fields, assessment, monitoring and evaluation of student learning. • Certification by the head of the department or college dean that the STEAM faculty **facilitated** collaborative planning, selecting, implementing, and monitoring assessment and evaluation of student learning, feedback system and designing of assessment-based program and plan of action. • Copy of the assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester • Results of the assessment and performance highlighting understanding of the lesson by the STEAM learners. • Minutes of Meeting stipulating facilitation of Department-level, College-level, and attendance and participation to Institution-level discussion on assessment results for instructional planning • Others (please specify and provide annotations)

Table 4. Required Documents for Verification (Highly Proficient)

	Career Stage 2 Highly Proficient/Competent	Required Documents for Verification
Professional Development and Personal Growth	They continually aspire to improve their professional and personal growth through knowledge creation, and dissemination, and collaboration with experienced colleagues and STEAM experts and professionals on discipline and on content and teaching the STEAM discipline.	• Certificate of Appreciation or Recognition as resource speaker in teaching the STEAM discipline or in the STEAM discipline • Certificate of Appreciation or Recognition as resource speaker in Research and Publication Capability Building Programs • Certificates for Presentation of Research in national, regional or international research (Scopus- and ISI-indexed) fora • Active Membership (e.g., joins committee, holds a position in the board) to Professional Organizations • Invited as resource speaker in teaching the STEAM discipline or in the discipline • Authorship of textbooks or published instructional materials, and research publications (*CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals)* • With a number of research citations (h-index [google scholar] of at least 3 • Certificate of significant contribution to the community • Student Evaluation • Others (please specify and provide annotations)

Table 5. Required Documents for Verification (Distinguished)

	Career Stage 2 Distinguished/Expert	Required Documents for Verification
General Attributes of STEAM Educator	Distinguished STEAM Educators mentor colleagues and initiate policy inputs to exemplify the highest standard for STEAM education grounded on local and national perspectives, and research-based undertakings, anchored on globally-acclaimed best and finest suitable practices and principles.	• Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (Undergraduate degree program) • Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (for Graduate degree-Masters) • Transcript of Record or Diploma in any of the STEAM Disciplines stipulating completion of any of the STEAM Program (**for Graduate degree-Doctorate Degree**) • School-based merit system or promotion system (for private HEIs and LUCs) document of proficiency as a tertiary educator or Rating **(for Full Professor level) based on Faculty Ranking and Promotion of NBC 461 (for SUCs)** • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Active Membership (e.g., chair of committee, holds a position in the board) to Professional Organizations • Invited as resource speaker in teaching the STEAM discipline or in the discipline • Certificates for Appreciation or Recognition as Plenary Speaker in Research Conferences and Fora in national, regional or international research fora (Scopus-indexed and ISI-indexed fora) • Certificate of mentorship of graduate students (masters program and doctorate programs) • Authorship of tertiary textbooks, edited books which are internationally-published or published instructional materials, and research publications (*CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals)* • With a number of research citations (h-index[google scholar] of at least 5 • Patent/inventions/discoveries or utility model certifications • Certificate of Project/Program Leadership of funded research (national and/or international) • Recipient of National and/or International Awards • Certificate of significant contribution to the community • Student Evaluation • Others (please specify and provide annotations)

Table 5. Required Documents for Verification (Distinguished)

	Career Stage 2 Distinguished/Expert	Required Documents for Verification
Knowledge of STEAM Discipline	Their exceptional capacity to acquire knowledge and exemplar practice to improve knowledge on STEAM disciplines and in the fields of research, languages and communication utilizing STEAM meta-discipline to develop Filipino learners' STEAM skills (e.g., design thinking skills, time management, technical know-how, and cognitive and emotional intelligences) responsive to national and global goals is shown in their ability to train others in acquiring a strong understanding of the discipline.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the use of STEAM as a meta-discipline, to **facilitate research-based teaching**, and the faculty's ability to use the findings and products of STEAM research to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Certificate or minutes of meeting or workshop stipulating initiating programs for mentoring colleagues and collaborative development of instructional materials, specific discipline-based technology, and teaching tools in teaching and learning of the STEAM discipline of STEAM learners. • Certificate or minutes of meeting or workshop stipulating initiating programs for mentoring colleagues and collaborative development of assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester. • Results of the assessment and performance highlighting an **in-depth** understanding of the lesson by the STEAM learners and **acquisition of 21st century skills** such as design thinking, critical thinking, innovativeness, technical know-how, and cognitive and emotional intelligences. • Certificate of Appreciation or Recognition as Lead Speaker or Plenary Speaker in workshops, seminars and training on teaching the STEAM discipline or in the STEAM discipline. • Authorship of textbooks or published instructional materials, and research publications (*CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals)* Copy of student evaluation • Others (please specify and provide annotations)

Table 5. Required Documents for Verification (Distinguished)

	Career Stage 2 Distinguished/Expert	Required Documents for Verification
Research-based knowledge of STEAM disciplines	They exemplify knowledge generation, dissemination, and knowledge sustainability for professional practice, community service to promote the welfare of STEAM profession in schools and the community as well.	• Program or Discipline-based required standard related to research (*copy of research proposal of a locally-funded research, completed research, publication in CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals*). • Documents (e.g., MOA) stipulating facilitation of or initiation of Institutional research collaborations to develop STEAM products for copyright and patents • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Active Membership (e.g., chair of committee, holds a position in the board) to Professional Organizations • Invited as resource speaker in teaching the STEAM discipline or in the discipline • Certificates for Appreciation or Recognition as Plenary Speaker in Research Conferences and Fora in national, regional or international research fora (Scopus-indexed and ISI-indexed fora) • Certificate of mentorship of graduate students (masters program and doctorate programs) • Authorship of tertiary textbooks, edited books which are internationally-published or published instructional materials, and research publications (*CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals)* • With a number of research citations (h-index[google scholar] of at least 5 • Patent/inventions/discoveries or utility model certifications • Certificate of Project/Program Leadership of funded research (national and/or international) • Copy of published book or instructional materials • Certificate of significant contribution to the community • Others (please specify and provide annotations)

Table 5. Required Documents for Verification (Distinguished)

	Career Stage 2 Distinguished/Expert	Required Documents for Verification
Knowledge, Skills and Values for STEAM teaching and learning processes	They are recognized as groundbreakers in STEAM education, contributors to the STEAM profession and initiators of collaborations that can forge productive and innovative products, programs and curricula through local and international partnerships. They 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 professionals, colleagues, diverse learners/students and the community.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the use of STEAM as a meta-discipline, to **facilitate research-based teaching**, and the faculty's ability to use the findings and products of STEAM research to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Certificate or minutes of meeting or workshop stipulating initiating programs for mentoring colleagues and collaborative development of instructional materials, specific discipline-based technology, and teaching tools in teaching and learning of the STEAM discipline of STEAM learners. • Certificate or minutes of meeting or workshop stipulating initiating programs for mentoring colleagues and collaborative development of assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester. • Minutes of Meeting stipulating initiating programs for mentoring colleagues on Institution-level curricular workshops. • Memorandum stipulating that STEAM educator Chairs or co-chairs the curricular or curriculum committee (institutional-level). • Document stipulating participation of the STEAM faculty in national curricular reforms (CHED or DepEd) • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Certificate of Appreciation or Recognition as resource speaker in teaching the STEAM discipline or in the STEAM discipline • Others (please specify and provide annotations)

Table 5. Required Documents for Verification (Distinguished)

	Career Stage 2 Distinguished/Expert	Required Documents for Verification
Assessment, Monitoring Learning and Feedback System	They model, exemplify, and mentor planning, selecting, implementing and monitoring assessment and evaluation of student learning, feedback system and designing of assessment-based programs and plan of actions for better progress in student learning.	• Classroom Observation Rating Tool (Rating Scale, Notes, Technology Integration Checklist, Assessment Checklist) • Copy of their session guide and syllabus focused teaching program (embedding knowledge of the discipline, pedagogy, assessment, and technology integration) that emphasizes the use of STEAM as a meta-discipline, to **facilitate research-based teaching**, and the faculty's ability to use the findings and products of STEAM research to organize the teaching-learning process to enable students to learn the required concepts in the STEAM discipline. • Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Copy of student evaluation • Copy of Certificate of Recognition or Appreciation as Resource Speaker or Plenary Speaker in seminars and trainings on teaching strategies in STEAM fields, assessment, monitoring and evaluation of student learning. • Certification by the head of the department or college dean that the STEAM faculty **initiated** collaborative planning, selecting, implementing, and monitoring assessment and evaluation of student learning, feedback system and designing of assessment-based program and plan of action (Institution-wide). • Copy of the assessment (with TOS) and performance tasks (with Rubrics) used in the course within the term or semester • Results of the assessment and performance highlighting understanding of the lesson by the STEAM learners. • Minutes of Meeting stipulating initiating of College-level, and/or Institution-level discussion on assessment results for instructional planning • Others (please specify and provide annotations)

Table 5. Required Documents for Verification (Distinguished)

	Career Stage 2 Distinguished/Expert	Required Documents for Verification
Professional Development and Personal Growth	They sustainably advance and pursue excellence in STEAM quality teaching and research and commits to inspire the education community and stakeholders for the improvement of education provision in the Philippines.	• Proficiency Rating using the Proficiency Indicators for Philippine STEAM Educators • Active Membership (e.g., chair of committee, holds a position in the board) to Professional Organizations • Invited as resource speaker in teaching the STEAM discipline or in the discipline • Certificates for Appreciation or Recognition as Plenary Speaker in Research Conferences and Fora in national, regional or international research fora (Scopus-indexed and ISI-indexed fora) • Certificate of mentorship of graduate students (masters program and doctorate programs) • Authorship of tertiary textbooks, edited books which are internationally-published or published instructional materials, and research publications (*CHED-accredited journals, Scopus-indexed journals and Clarivate Analytics-indexed journals)* • With a number of research citations (h-index[google scholar] of at least 5 • Patent/inventions/discoveries or utility model certifications • Certificate of Project/Program Leadership of funded research (national and/or international) • Recipient of National and/or International Awards • Certificate of significant contribution to the community • Student Evaluation • Others (please specify and provide annotations)

The Models

A. PEDAGOGICAL MODEL

A.1. Validated

The STEAM Pedagogical Model in Philippine Higher Education Institutions (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. Planning the pedagogical processes specifically ensures alignment of learning objectives and activities, alignment of faculty specialization and content taught, partnership between school and industry, and emphasis of the relevance of STEAM to the community. An institutional pedagogical culture likewise entails disseminating institutional pedagogical policies and curricular reforms, programs, and innovations. Evaluation of pedagogical processes entails periodic institutional review of curriculum and evaluation of teachers' pedagogical processes and consequently drawing implications for ranking, promotion, and continuing professional development. Pedagogical culture further promotes mentoring among faculty members, and 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" pattern, the institutional pedagogical processes and teachers' pedagogical character exemplify the institution's pedagogical culture. This suggests that pedagogical processes likewise entail planning, facilitating, and monitoring learning, as well as establishing a mentoring mechanism for learners. The Philippine STEAM pedagogical model emphasizes inquiry-based and output/product-based learning and teaching and a spectrum of related teaching practices. Further, it promotes ethical conduct of STEAM pedagogical processes and research for continuous improvement of STEAM pedagogy.

A teacher's epistemological beliefs and teaching practices comprise his pedagogical character. STEAM teachers acknowledge that there is no perfect teaching strategy. This 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 are adept in switching across strategies whenever appropriate and necessary. STEAM teachers likewise model learning by linking practice and teaching and demonstrating critical and reflective thinking.

The Pedagogical model of Philippine STEAM Education explicates that the nexus between an institution's pedagogical culture and its pedagogical processes is gauged by the quality of its learners and teachers. Specifically, the 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.

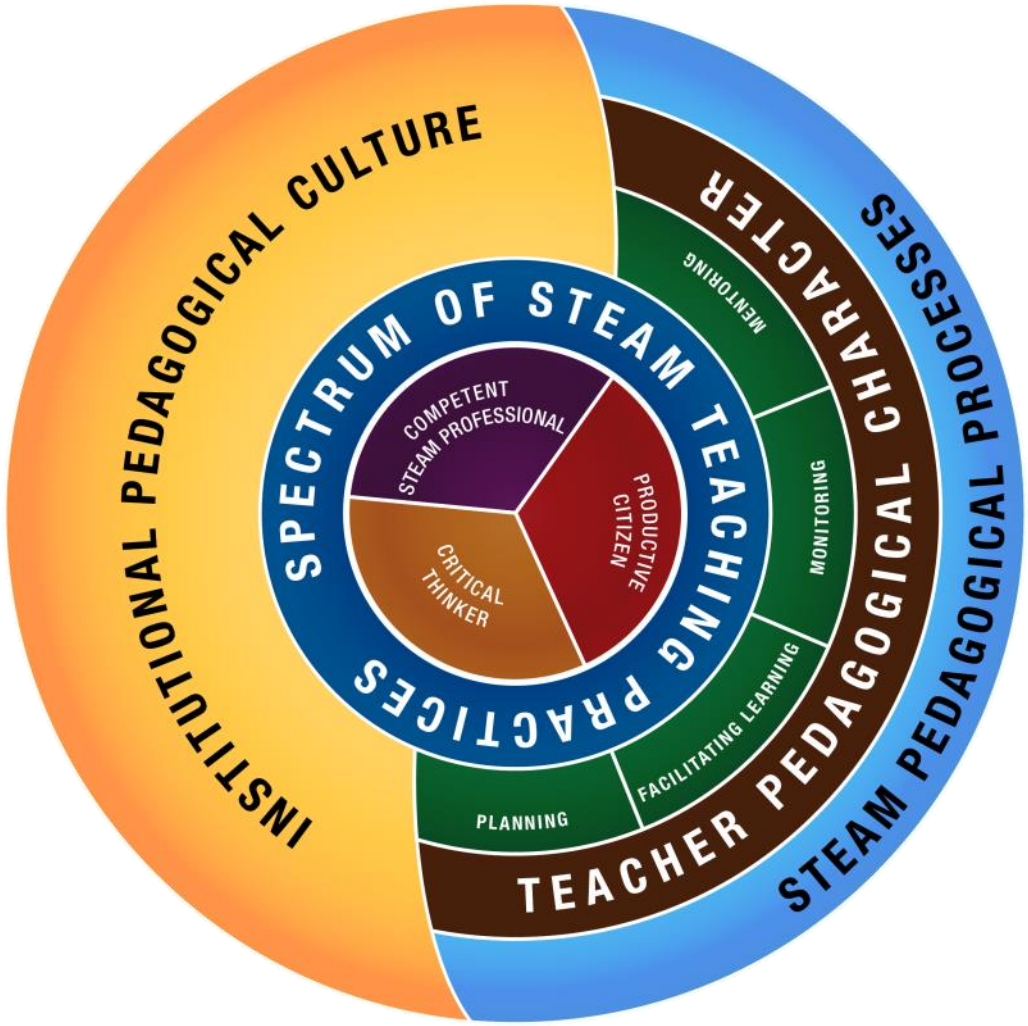

Figure 4. Pedagogical Model (Validated)

A.2. Emerging

The STEAM Pedagogical Model in Philippine Higher Education Institutions (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. Planning the pedagogical processes specifically ensures alignment of learning objectives and activities, alignment of faculty specialization and content taught, partnership between school and industry, and emphasis of the relevance of STEAM to the community. An institutional pedagogical culture likewise entails disseminating institutional pedagogical policies and curricular reforms, programs, and innovations. Evaluation of pedagogical processes entails periodic institutional review of curriculum and evaluation of teachers' pedagogical processes and consequently drawing implications for ranking, promotion, and continuing professional development. Pedagogical culture further promotes mentoring among faculty members, and tenders continuing professional development opportunities for teachers.

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A teacher's epistemological beliefs and teaching practices comprise his pedagogical character. STEAM teachers acknowledge that there is no perfect teaching strategy. This 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 are adept in switching across strategies whenever appropriate and necessary. STEAM teachers likewise model learning by linking practice and teaching and demonstrating critical and reflective thinking.

The Pedagogical model of Philippine STEAM Education explicates that the nexus 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 21st century-skilled human resource, productive citizens, and competent STEAM professionals. The circular frame of the model depicts sustainability of every relationship demonstrated by its variables and dimensions.

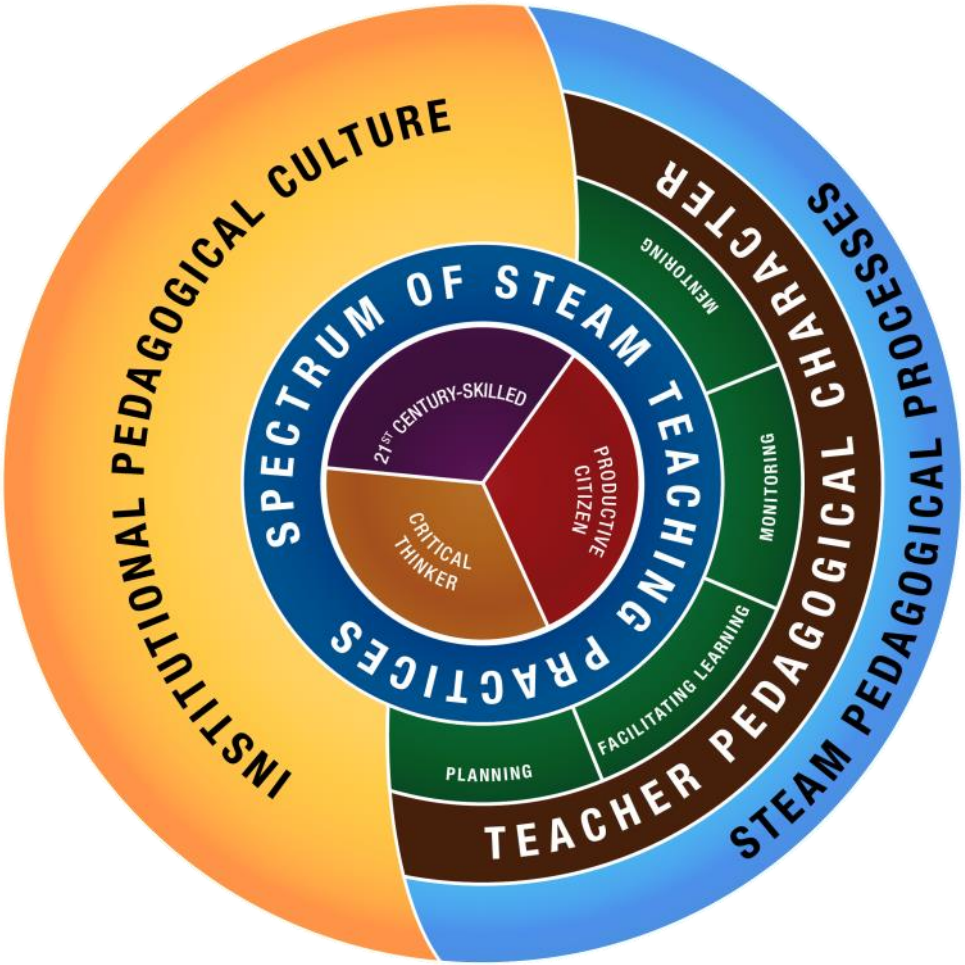


Figure 5. Pedagogical Model (Emerging)

B. ASSESSMENT MODEL

B.1. Validated

The STEAM Assessment Model (Figure 6) highlights the four variables and thirteen dimensions that influence the overall framework of the Philippine STEAM Education. The first three variables are represented as concentric circles that encapsulate the fourth.

The first variable includes the (A) **"Enablers"** of STEAM Assessment which occupies the outermost layer of the model. This variable has two dimensions, (1) ***Institutional Affordances*** and (2) ***Sustainability***, and considered crucial as this variable highlights the capabilities, forces, and resources that contributes to the success of the assessment process. The first dimension refers to the properties, facilities and policies of educational institutions or an aspect of its environment that describes and aids their STEAM assessment process. The second dimension pertains to the efforts and practices exerted to secure, maintain, and improve the quality of the STEAM assessment process; involving the various research initiatives that aims to oversee and enhance assessment. The connection between the two dimensions indicates the significant linkage between the two and how one influences the other.

The second variable are the (B) **"Drivers"** of STEAM Assessment. It is displayed as the next layer of the model that enumerates the key factors and main considerations in the STEAM assessment process and direction. These factors are categorized into three dimensions, which are: (3) ***Equity and Diversity***, (4) ***Collaboration***, and (5) ***Modality***. By and large, these three dimensions ensure the inclusion of all types of learners, accommodation of the context and locale of the students, and making certain that each has a fair and equal opportunity during the assessment process; maintain the dynamic and engaging interactions that exist between various key players in the assessment process; and bestow the use of varied and appropriate tools and methods for various purposes of assessment in the STEAM learning-teaching discourse.

The third variable enumerates the (C) **"Processes"** of STEAM Assessment, which is found in the third inner layer of the model. This variable identified five stages which depict the last five dimensions of the model. These are (6) ***Planning and Preparation***, (7) ***Implementation***, (8) ***Rating***, (9) ***Reporting***, and (10) ***Reflection***. They represent the different phases of reflective instruction where assessment principles are observed and practiced. The arrows pointing from one stage to the other symbolizes that the STEAM assessment follows a specific order and the cyclical nature of the process. Furthermore, the Process of STEAM Assessment, with its corresponding indicators (correlated with the Drivers of STEAM Assessment) commands the assortment of STEAM assessment practices. It also defines the attributes of teaching competencies, as well as, establishes the requirements for advancement in each career stage (Beginner, Proficient, Highly Proficient, Distinguished) of a STEAM educator.

The last variable, appearing at the kernel of the model, specifies the desired (D) "**Outcomes**" of STEAM Education. It set forth the intended trait and characteristics of STEAM learners and graduates, categorized into three dimensions. These are to be (11) ***Innovative STEAM Professional Learner***, (12) ***Critical Thinker***, and (13) ***Productive Citizen*** (members of the society); which also serves as a metric of a successful delivery of STEAM education.

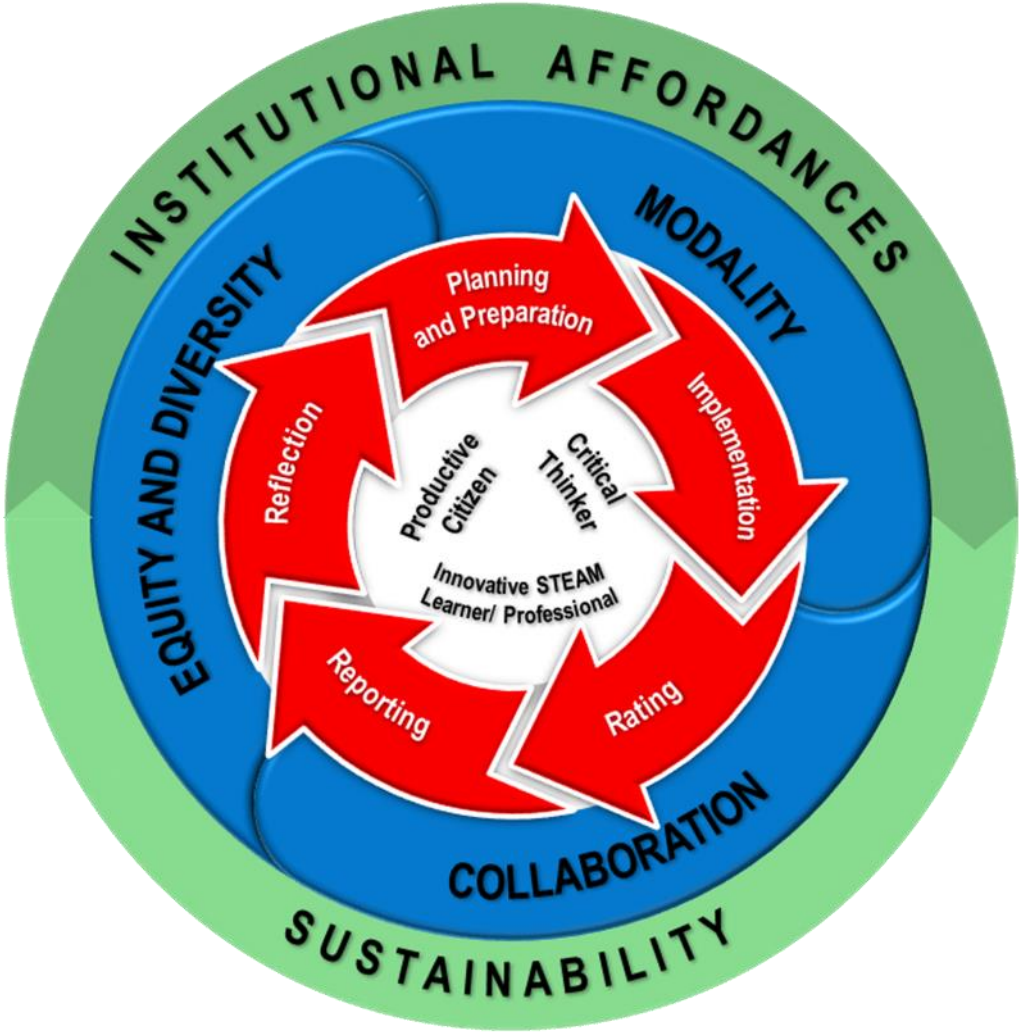


Figure 6. Assessment Model (Validated)

B.2. Emerging

The STEAM Assessment Model (Figure 7) highlights the four variables and fourteen dimensions that influence the overall framework of the Philippine STEAM Education. The first three variables are represented as concentric circles that encapsulate the fourth.

The first variable includes the (A) **"Enablers"** of STEAM Assessment which occupies the outermost layer of the model. This variable has two dimensions, (1) ***Institutional Affordances*** and (2) ***Sustainability***, and considered crucial as this variable highlights the capabilities, forces, and resources that contributes to the success of the assessment process. The first dimension refers to the properties, facilities and policies of educational institutions or an aspect of its environment that describes and aids their STEAM assessment process. The second dimension pertains to the efforts and practices exerted to secure, maintain, and improve the quality of the STEAM assessment process; involving the various research initiatives that aims to oversee and enhance assessment.. The connection between the two dimensions indicates the significant linkage between the two and how one influences the other.

The second variable are the (B) **"Drivers"** of STEAM Assessment. It is displayed as the next layer of the model that enumerates the key factors and main considerations in the STEAM assessment process and direction. These factors are categorized into four dimensions, which are: (3) ***Equity and Diversity***, (4) ***Collaboration***, (5) ***Modality*** and (6) ***Innovation***. By and large, these three dimensions ensure the inclusion of all types of learners, accommodation of the context and locale of the students, and making certain that each has a fair and equal opportunity during the assessment process; maintain the dynamic and engaging interactions that exist between various key players in the assessment process, bestow the use of varied and appropriate tools and methods for various purposes of assessment, and incorporate creativity and problem solving skills in utilizing and maximizing resources in the STEAM learning-teaching discourse.

The third variable enumerates the (C) **"Processes"** of STEAM Assessment, which is found in the third inner layer of the model. This variable identified five stages which depict the last five dimensions of the model. These are (7) ***Planning and Preparation***, (8) ***Implementation***, (9) ***Rating***, (10) ***Reporting***, and (11) ***Reflection***. They represent the different phases of reflective instruction where assessment principles are observed and practiced. The arrows pointing from one stage to the other symbolizes that the STEAM assessment follows a specific order and the cyclical nature of the process. Furthermore, the Process of STEAM Assessment, with its corresponding indicators (correlated with the Drivers of STEAM Assessment) commands the assortment of STEAM assessment practices. It also defines the attributes of teaching competencies, as well as, establishes the requirements for advancement in each career stage (Beginner, Proficient, Highly Proficient, Distinguished) of a STEAM educator.

The last variable, appearing at the kernel of the model, specifies the desired (D) "**Outcomes**" of STEAM Education. It set forth the intended trait and characteristics of STEAM learners and graduates, categorized into three dimensions. These are to be (12) ***Innovative STEAM Professional Learner***, (13) ***Critical Thinker***, and (14) ***Productive Citizen*** (members of the society); which also serves as a metric of a successful delivery of STEAM education.

Figure 7. Assessment Model (Emerging)

C. TECHNOLOGY INTEGRATION MODEL

C.1. Validated

Technology integration refers to the use of technology resources -- computers, mobile devices like smartphones and tablets, digital cameras, social media platforms and networks, software applications, the Internet, etc. in learning, in daily classroom practices, in teachers' major and other duties, and in the management of a school (Edutopia, 2007; Education4site, 2011). The technology integration model for STEAM education shows three variables: *teacher technological knowledge (TTK), institutional support (IS)* and *outcomes*. **Teacher technological knowledge (TTK)** refers to the understanding of teachers about technology. This includes familiarity to various technology, understanding how to make and use specific technology to identified lessons, and assessing when technology assist or impede lesson delivery. Teacher technology knowledge has two dimensions, lesson structure and content-driven. *Lesson structure* pertains to the integration of technology in specific parts of the lesson, at most, for faster lesson delivery and better presentation. *Content-driven* is the use of technology in instruction specifically applicable to courses on which the content of the course is bound to technology use. On the other hand, **Institutional Support (IS)** has two dimensions: capacity building and quality of technology, architecture, system and design. *Capacity building* is to enhance technological literacy of teachers in the appropriate use of technology for specific purpose. It includes trainings and workshops for teachers in the proper use of technology. *Quality of technology, architecture, design and system* refers to various software, applications, devices and other instruments that the teachers need to carry out the teaching-learning process. This is approximated by the affordability, availability and appropriateness of the technology used in instruction and/or assessment. Current and modern designs to ensure the comfortable use of technology in teaching and learning are essential to produce *critical thinkers, productive citizens and innovative STEAM professionals* in promoting quality STEAM education.

The model theorizes using the TPACK, SAMR and Triple E framework with emphasis on Triple E: *engagement, enhancement and extension*. The model shows no barriers that divide the dimensions of the variables to signify that these dimensions are related to one another. Similarly, the Triple E Framework are observed in the outermost circle to denote that technology integration can be a way to evaluate how to select tools to meet the learning goals, and design learning episodes using tools that impact students to deduce the desired learning outcome.

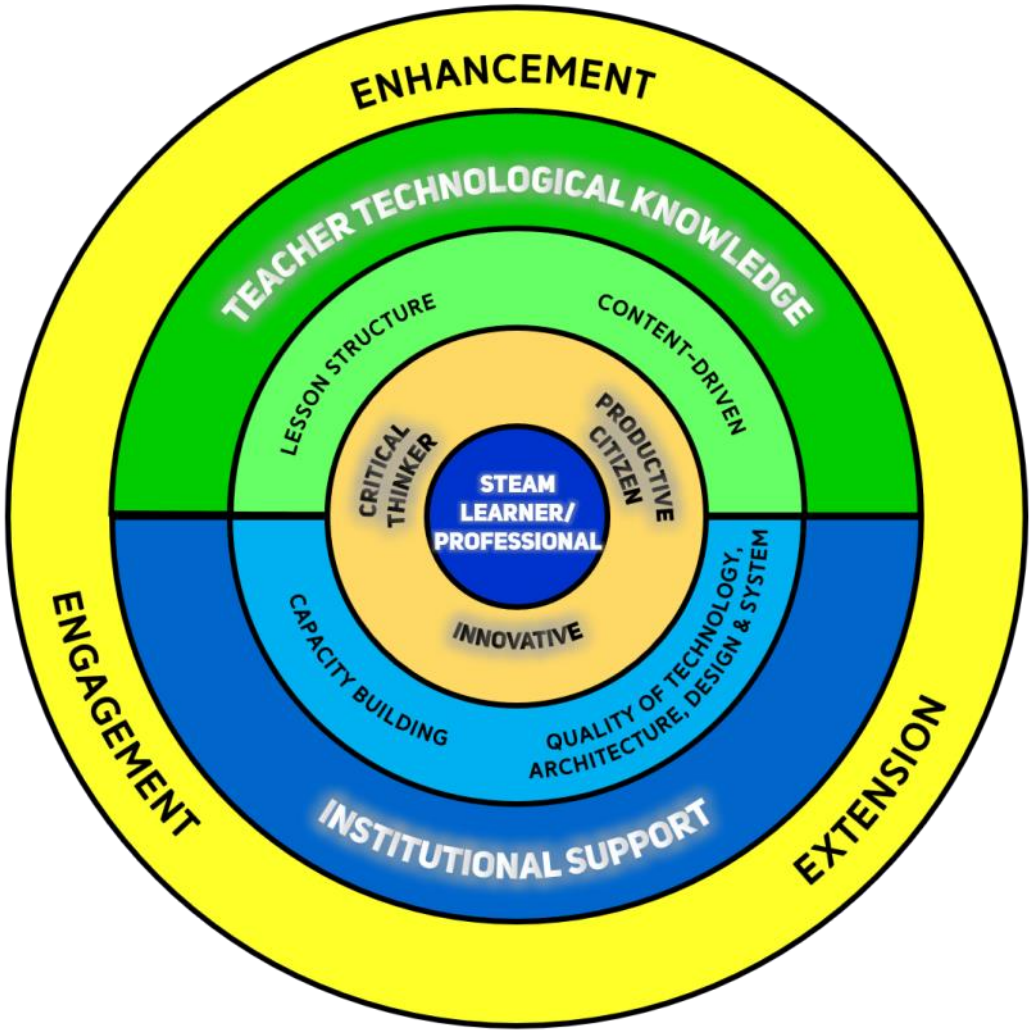


Figure 8. Technology Integration Model (Validated)

C.2. Emerging

The emerging technology integration model resulted from the two-tier validation. The same variables are present in the model: teacher technological knowledge, institutional support and outcomes. The emerging model has additional one dimension each under teacher technological knowledge and institutional support. Context-based under the teacher technological knowledge refers to the conditions, physical, economic or cultural, of the school, teachers including the students. Further, under institutional support added one dimension: research in technology development. Research in technology development refers to the dimension of institutional support that creates opportunities to innovate and develop technology related to STEAM disciplines. Moreover, one of the outcomes of being a STEAM learner/ profession is to possess 21st century skills.

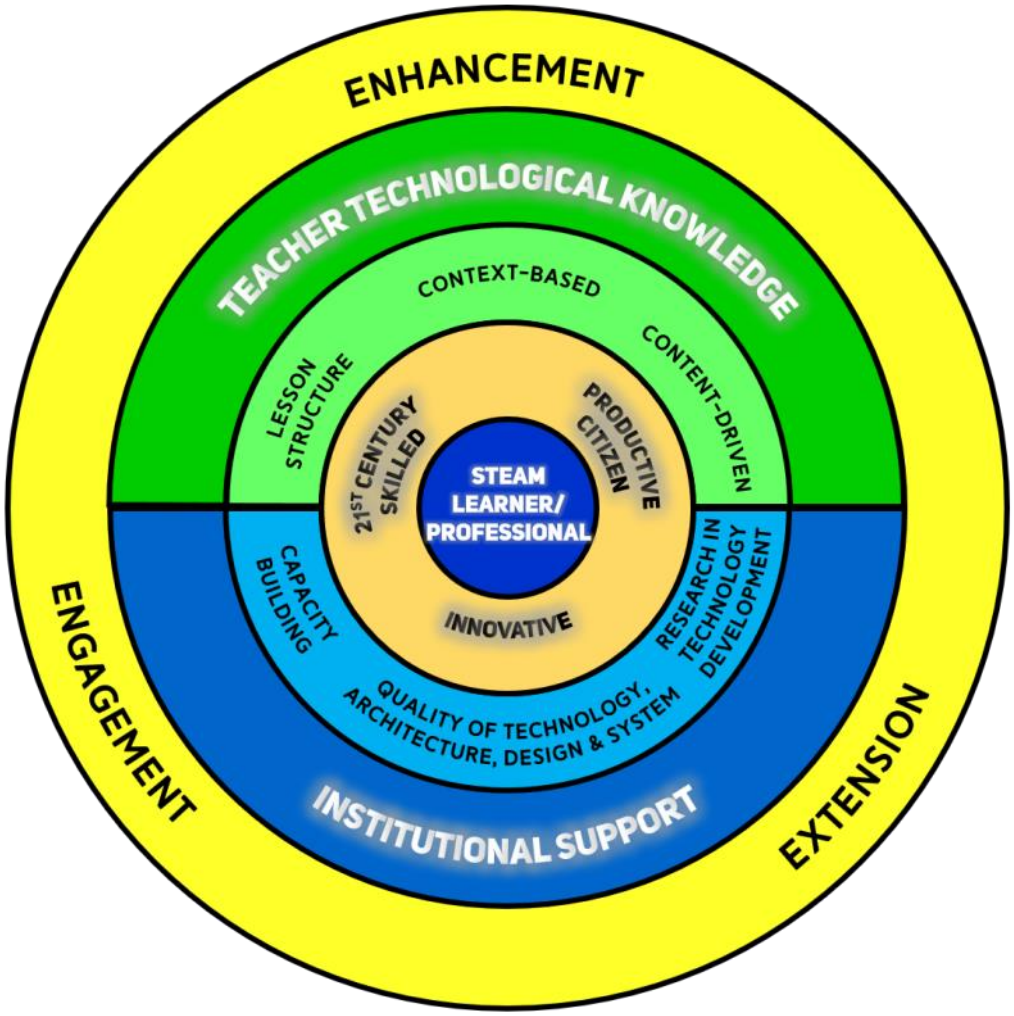
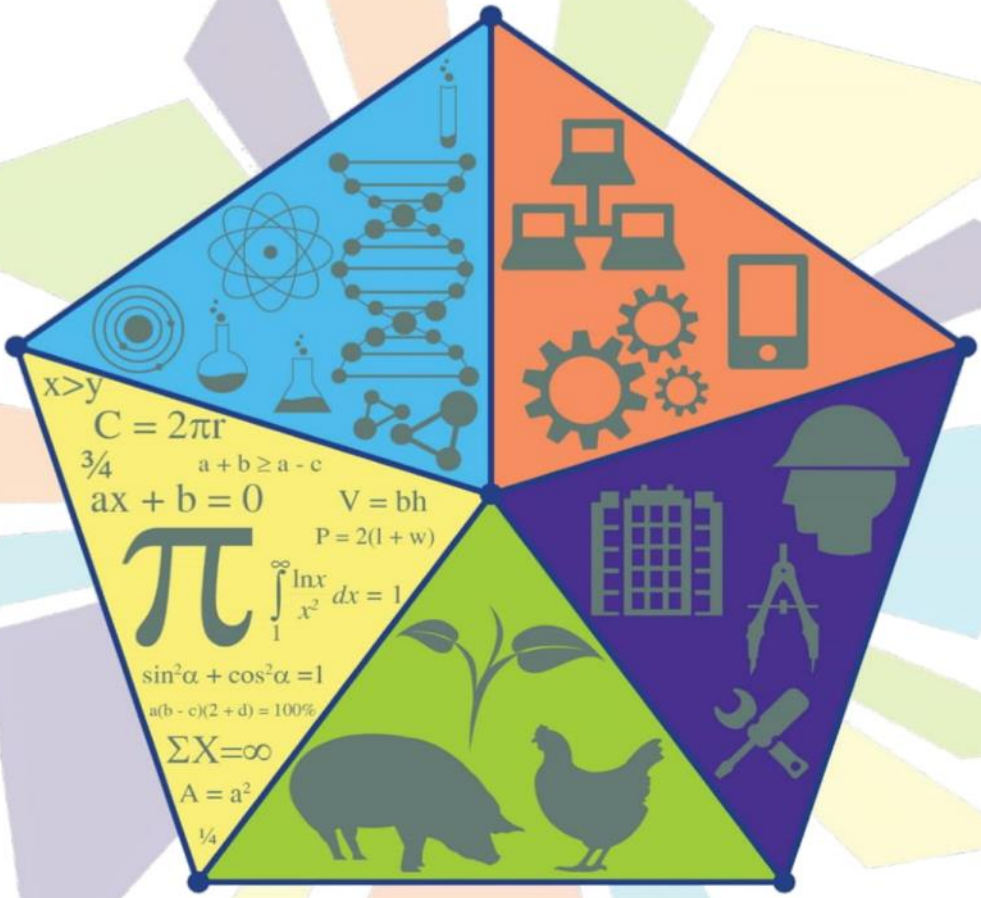


Figure 9. Technology Integration (Emerging)



STEAM Educators Proficiency Indicators

CHED - PNU
TPACK
STEAM EDUCATION

APPENDIX A

(02) 317-1768 local 530
0906-3719733 / 0923-9324884 (Nica A. Casilla, Technical Staff)
steam@pnu.edu.ph
https://www.facebook.com/TPACK.CHED/

STEAM EDUCATORS PROFICIENCY INDICATORS

Informed Consent Form

Being over the age of 18 years old (legally independent), I hereby consent to participate in the research project titled: "Technological-Pedagogical-Assessment-Content-Knowledge (TPACK) in STEAM Education" by answering the herein STEAM EDUCATORS PROFICIENCY INDICATORS

I am aware that my participation is voluntary in nature;

I understand that I may not directly benefit from taking part in this research;

While the information gained in this study will be published as a research article, I will not be identified, and individual information will remain confidential;

Any information and related data obtained during the pilot testing shall be used solely for research and academic purposes; and

I may provide comment/s and suggestion/s to the items in the research instrument and the process of pilot testing as I deemed necessary.

Dear Respondent,

The Philippine Normal University would like to know your level of proficiency as a STEAM Educator. Please rate yourself in terms of the indicators/attributes listed by highlighting the choice of your answer.

Scale to use (4-point scale):

4 = Always true to myself
3 = Often true to myself
2 = Occasionally true to myself
1 = Rarely true to myself
N/A = Not applicable

This self-rating scale may inform the level of STEAM Educator Proficiency as Beginning STEAM Educator, Proficient STEAM Educator, Highly Proficient STEAM Educator, and Distinguished STEAM Educator.

Thank you for taking time in answering.

PNU Researchers

*E-mail Address: _____

Name (Optional): _____

*Gender: _____

*Age: _____

*School Affiliation: _____

*Address: _____

*No. of Years of STEAM Teaching: _____

*Specific Area/Field (Science, Technology, Engineering, Agriculture, or Mathematics) _____

*Subject being taught _____

*Year Level being taught _____

Item No.	Indicators	4	3	2	1	N/A
1	Possesses content knowledge on STEAM (Science, Technology, Engineering, Agriculture, and Mathematics).	☐	☐	☐	☐	☐
2	Demonstrates content knowledge on core STEAM courses.	☐	☐	☐	☐	☐
3	Demonstrates content knowledge on STEAM-related fields (i.e., research, language and communication).	☐	☐	☐	☐	☐
4	Demonstrates STEAM-related laboratory/clinical skills.	☐	☐	☐	☐	☐

3

5	Possesses knowledge on related industry/community as service providers.	☐	☐	☐	☐	☐
6	Exhibits knowledge on STEAM fields (content and skills) responsive to national goals and global concerns.	☐	☐	☐	☐	☐
7	Plans, conducts, and disseminates STEAM-related research.	☐	☐	☐	☐	☐
8	Designs, improves, innovates, and supervises basic to advance systems and/or procedures as solutions to local and global problems within realistic constraints.	☐	☐	☐	☐	☐
9	Utilizes research outputs to enhance professional practice and to address national and global concerns.	☐	☐	☐	☐	☐
10	Develops/Improvises new technology (software, laboratory equipment, and teaching materials) using locally available resources to advance effective and efficient practice of the profession.	☐	☐	☐	☐	☐
11	Uses modern statistical and computing techniques and tools in predicting future trends and processes of STEAM.	☐	☐	☐	☐	☐
12	Familiarizes with database relevant to the STEAM profession.	☐	☐	☐	☐	☐
13	Uses advanced and research-based techniques and tools in teaching STEAM content knowledge.	☐	☐	☐	☐	☐
14	Communicates effectively across multiple platforms, both oral and written, especially in the English language.	☐	☐	☐	☐	☐
15	Seeks out information on subject related research, e.g., via journals or by attending conferences.	☐	☐	☐	☐	☐
16	Facilitates development of reflective and critical thinking among students.	☐	☐	☐	☐	☐
17	Promotes inquiry attitude through questioning.	☐	☐	☐	☐	☐
18	Facilitates active classroom discussion using inquiry learning strategies (project-based, problem-based, product-based).	☐	☐	☐	☐	☐
19	Allows flexible channels of communication to get across students of different abilities and comprehension skills and even allows occasional use of mother tongue to help express themselves or their answers better (then translate them to a common language for everyone to appreciate and learn from).	☐	☐	☐	☐	☐
Comment for Item Nos. 1-19						
20	Observes precautionary measures in the laboratory rooms and classrooms (fire extinguishers, fire force) alarm systems, and campus security.	☐	☐	☐	☐	☐
21	Facilitates ethical use of online resources.	☐	☐	☐	☐	☐

4

22	Promotes working effectively in multidisciplinary and multi-cultural teams.	☐	☐	☐	☐	☐
23	Exhibits capability to facilitate large classes.	☐	☐	☐	☐	☐
24	Promotes proper care and handling of laboratory instruments, tools, equipment, online systems, virtual laboratories, and software.	☐	☐	☐	☐	☐
25	Promotes seamless transition of topics and establishes relevant relationship of concepts.	☐	☐	☐	☐	☐
26	Utilizes teaching strategies suited to diverse learners.	☐	☐	☐	☐	☐
27	Monitors each student by establishing eye contact, walking around the area, being aware of what's happening in the class during sessions, site visits, field trips, tours, and other supervised visits.	☐	☐	☐	☐	☐
28	Models various scientific attitudes and STEAM professional traits.	☐	☐	☐	☐	☐
29	Promotes the concept of voluntary service by making students carry out classroom-related duties (e.g., monitoring cleanliness and orderliness in the classroom).	☐	☐	☐	☐	☐
Comment for Item Nos. 20-29						
30	Facilitates lessons and activities that are suited to the students' interests and individual differences and do not discriminate any cultural groups and are sensitive to students' needs.	☐	☐	☐	☐	☐
31	Arranges opportunities for students to learn by allowing them to form varied group structures (solo, pair, groups, and teams).	☐	☐	☐	☐	☐
32	Develops gender-sensitive instructional materials.	☐	☐	☐	☐	☐
33	Takes into consideration the cultural, social, and emotional differences among students.	☐	☐	☐	☐	☐
34	Prepares materials and lessons appropriate to specific learning capability.	☐	☐	☐	☐	☐
35	Facilitates peer learning to support other students cognitively and affectively.	☐	☐	☐	☐	☐
36	Listens skillfully, reasonably, and patiently to his or her students during consultation.	☐	☐	☐	☐	☐
Comment for Item Nos. 30-36						

37	Possesses knowledge on curricular programs including goals and framework.	☐	☐	☐	☐	☐
38	Engages the students in planning and achieving the learning outcomes.	☐	☐	☐	☐	☐
39	Utilizes various teaching methods.	☐	☐	☐	☐	☐
40	Applies current trends, practices, and innovations in the teaching process.	☐	☐	☐	☐	☐
41	Uses updated syllabi and teaching methods to meet the desired learning outcomes.	☐	☐	☐	☐	☐
42	Ensures that the learning outcomes are attained.	☐	☐	☐	☐	☐
43	Designs, communicates, and implements STEAM-related activities in partnership with the community/industry.	☐	☐	☐	☐	☐
44	Uses multimedia and other learning resources like journals and online materials in the teaching and learning process.	☐	☐	☐	☐	☐
45	Adapts and utilizes STEAM technologies in the teaching and learning process.	☐	☐	☐	☐	☐
Comment for Item Nos. 37-45						
46	Selects standard assessment methods appropriate for instructional decisions.	☐	☐	☐	☐	☐
47	Recognizes unethical, illegal and otherwise inappropriate assessment methods and uses of assessment information.	☐	☐	☐	☐	☐
48	Possesses skills in using assessment results when making decisions about individual students, planning teaching, developing curriculum, and school improvement.	☐	☐	☐	☐	☐
Comment for Item Nos. 46-48						
49	Emphasizes the effects and impacts of the STEAM disciplines to the community and society.	☐	☐	☐	☐	☐
50	Conducts STEAM-related activities involving the learners, parents and the community.	☐	☐	☐	☐	☐

51	Demonstrates dedication and commitment to work with honesty and integrity.	☐	☐	☐	☐	☐
52	Recognizes and understands the professional, social and ethical responsibilities of the STEAM profession.	☐	☐	☐	☐	☐
53	Practices STEAM profession in accordance with the existing laws, legal, ethical and moral standards.	☐	☐	☐	☐	☐
54	Models the existing general policies, rules and regulations to promote the welfare of the STEAM professions.	☐	☐	☐	☐	☐
55	Observes the existing policies to better serve the students, the school, and the community.	☐	☐	☐	☐	☐
Comment for Item Nos. 49-55						
56	Maintains reputation as a pedagogical leader.	☐	☐	☐	☐	☐
57	Participates in seminars and conferences that may provide valuable inputs to make STEAM teaching relevant and responsive to the changing times.	☐	☐	☐	☐	☐
58	Uses appropriate modern techniques and tools necessary for the practice of STEAM profession in order to be globally competitive.	☐	☐	☐	☐	☐
59	Pursues higher learning (ex. graduate studies or short term courses) and accomplishes higher goals to advance in one's career stage.	☐	☐	☐	☐	☐
60	Engages in professional activities other than teaching (publish articles, conduct valuable and impactful research, take part in the curriculum development, re-echo seminars etc.) to further improve teaching competencies as well as leadership qualities and make a distinction in the field of science.	☐	☐	☐	☐	☐
Comment for Item Nos. 56-60						

REFERENCES

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). Computers & Education, 52(1), 154-168. doi: 10.1016/j.compedu.2008.07.006.

Aydın, S., Demirdöğen, B., Tarkın, A., & Uzuntiryaki, E. (2009). Effectiveness of a course on pre-service chemistry teachers' Pedagogical content knowledge and subject matter knowledge. In M.F. Taşar & G. Çakmakçı (Eds.), Contemporary science education research: pre-service and in-service teachers Education (pp. 59-69). Ankara, Turkey: Pegem Akademi.

Biglete, A.A. (2018). Proceedings form 2nd ASSERT National Convention on Outcome-Based Education (2nd ANC – OBE) Theme: "Addressing the Challenges and Prospects of the New Philippine Higher Education Curriculum through Digital and Outcome-Based Education." Manila, Philippines

Butter, M.C., Aguilera, E.M., Quintana, M.G.B., Perez, L.J., & Valenzuela, A.S. (2017). Quality Assurance for Postgraduate Programs: Design of a Model Applied on a University in Chile. The International Review of Research in Open and Distributed Learning, 18(1). https://doi.org/10.19173/irrodl.v18i1.2670.

Clark, J. (2010). Best Practices Research Summary. Sun Associates 2010. Retrieved from http://www.sun-associates.com/.

Clermont, C. P., Borko, H., & Krajcik, J. S. (1994). Comparative study of the pedagogical content knowledge of experienced and novice chemical demonstrations. Journal of Research in Science Teaching, 31 (4), 419-441.

[CHED] Commission on Higher Education. (2017). CHED Memorandum Order, No. 46, Series of 2012. Retrieved from https://ched.gov.ph/wp-content/uploads/2017/10/CMO-No.46-s2012.pdf.

Gardner, A.L., & Gess-Newsome, J. (2011). A PCK Rubric to Measure Teacher's Knowledge of Inquiry-Based Instruction Using Three Data Sources. [A paper presented at Annual Meeting of the National Association for Research in Science Teaching]. Retrieved from https://www.bscs.org/sites/default/files/_legacy/pdf/Community_Sessions_NARST2011_PCK%20Rubric%20Paper.pdf.

Geddis, A.N. (1993). Transforming subject-matter knowledge: The role of pedagogical content knowledge in learning to reflect on teaching. International Journal of Science Education, 15, 673- 683.

Gosselin, D. (n.d.) Competencies and Learning Outcomes. Retrieved from https://serc.carleton.edu/integrate/programs/workforceprep/competencies_and_LO.html.

Karaman, A. (2012). The Place of Pedagogical Content Knowledge in Teacher Education. Atlas Journal of Science Education, 2 (1): 56-60, doi: 10.5147/ajse.2012.009

REFERENCES

Kaya, O. N. (2009). The nature of relationships among the components of pedagogical content knowledge of pre-service science teachers: "Ozone layer depletion" as an example. International Journal of Science Education, 31 (7), 961-988.

Magnusson, S.; Krajcik, J.; Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N.G. Lederman (eds.), Examining pedagogical content knowledge, (pp. 95-132). Dordrecht, NL : Kluwer.

Mishra, P., & Koehler, M.J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. Teachers College Record, 108(6), 1017-1054.

Niess, M. L. (2008). Knowledge needed for teaching with technologies – Call it TPACK. AMTE Connections, 17(2), 9-10.

Park, S., Jang, J.-Y., Chen, Y.-C., & Jung, J. (2011). Is pedagogical content knowledge (PCK) necessary for reformed science teaching?: Evidence from an empirical study. Research in Science Education, 41, 245-260.

Park, S., & Oliver, J.S. (2007). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. Research in Science Education, 38(3), 261-284.

Philippine Development Plan 2017-2022. (2017). National Economic and Development Authority. Retrieved from http://pdp.neda.gov.ph/wp-content/uploads/2017/01/PDP-2017-2022-07-20-2017.pdf.

[PPST] Philippine Professional Standards for Teachers. (2017). Retrieved from http://www.deped.gov.ph/wp-content/uploads/2017/08/DO_s2017_042-1.pdf.

Policies, Standards & Guidelines. (2009). Retrieved from http://www.deped.gov.ph/.

Schmidt, D.A.; Baran, E.; Thompson, A.D.; Mishra, P.; Koehler, M. and Shin, T.S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. In Journal of Research on Technology in Education, 42(2), (pp. 123-149).

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), 4-14. doi: 10.3102/0013189X015002004.

REFERENCES

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. Harvard
Educational Review, 57(1), 1-22. doi:10.17763/haer.57.1.j463w79r56455411.
Thompson, A., & Mishra, P. (2007–2008). Breaking news: TPCK becomes TPACK! Journal of Computing in Teacher Education, 24(2), 38–64.

Uşak, M. (2005). Fen bilgisi öğretmen adaylarının çiçekli bitkiler konusundaki pedagojik alan bilgileri. Yayımlanmamış yüksek lisans tezi, Gazi Üniversitesi, Ankara.

Van Driel, J. H., Verloop, N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. Journal of Research in Science Teaching, 35 (6), 673-695.

Villaluz, E. (2005). Pedagogical Content Knowledge. Interactions Design and Teaching Practice of High School Biology Teachers, 88(15), 11.

Wright, L.L., & Lake, D.A. (n.d.). Basics of Research for the Health Professions. Retrieved from http://www.pt.armstrong.edu/wright/hlpr/text/3.4.depvar1.htm.

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