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TPACK IN PHILIPPINE STEAM EDUCATION

THE TECHNOLOGY INTEGRATION MODEL

CHAPTER 3

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ABSTRACT

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The Technology Integration Model

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The technology integration model unifies or consolidates technology in STEAM Education, its framework developed from the collected and analyzed qualitative data retrieved from the STEAM teachers across the country. The results derived three variables: *teacher technological knowledge (TTK), institutional support (IS)* and *outcomes*. Teacher technological knowledge has two dimensions: *lesson structure and content-driven*; just as the institutional support comes in tandem: *capacity building and quality of technology, architecture, design system*. The model gears up to realize three outcomes: to produce *innovative STEAM learner/professional, critical learner, and productive citizen*. The model theorizes using the TPACK, SAMR and Triple E framework with emphasis on Triple E: *engagement, enhancement and extension*. The two-tier validation to which the model was subjected helps create an emerging model. The emerging technology integration model has an additional dimension under TTK *(content-based)* and IS *(research in technology development*) and possessing 21st century skills as one of the outcomes of being a STEAM learner/professional. The technology integration model is believed to agree with the PSGs, assist with the PPST and strengthen the TPCK framework. The technology integration model may provide insights into reforms and policies to further technology integration in STEAM education.

Keywords: STEAM Education, technology integration, technology integration model

3.1. The Model Defined

3.1.1. Why the Technology Integration Model

Admittedly, Technology always has a special part in education. The use of technology such as tools, equipment and even nonphysical equipment like software and computer applications helps the teachers and students in teaching and learning STEAM disciplines. These roles are evident in the different components of teaching and learning; hence technology integration is essential in education. Technology integration refers to the use of technology resources (e.g., 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).

In the teaching-learning process, innovative teaching approaches are so essential in the students' learning experiences, that they provide learners with the necessary learning competence and experiences. Furthermore, in a STEAM classroom where learners are dynamic and diverse, these teaching innovations must be practiced by teachers to address the learners' multi-faceted needs. Consequently, these innovative teaching strategies could be best demonstrated with the integration of technology. The *21st Century skills* explicitly indicate the need for integrating the use of technology inside the classroom. Similarly, with the kind of students we have at present, they more often than not, learn best with the aid of technology such as educational software, audio-visual presentation, equipment and other related technology utilized inside a STEAM classroom.

Moreover, Education 4.0 directs all the teaching and learning processes in pursuit of all the demands of Industrial Revolution 4.0. It promotes a new learning vision and novel ways of learning that capitalize on collaboration of humans and machines (also known as cyber-physical system) (Atkinson, 2018). In the same view, it recalibrates the new learning terrain that centers on blending virtual and cyber-physical worlds into the realms of reality. Technology integration has a vital role in addressing the demands of Education 4.0, especially for STEAM education.

With the tenets of a quality STEAM education upheld, technology integration needs to be taken into so much consideration that technology integration model is developed. The current study looks into the domains of the model. Furthermore, the model proposes the emergence and importance of teacher technological knowledge and institutional support being used inside a dynamic STEAM classroom to produce quality STEAM leaners and professional.

3.1.2. The Technology Integration Model…

- Aims to describe the technology integration in quality STEAM education

- Has three major variables
  - **Teacher technological knowledge**
    - Lesson structure
    - Content-based
  - **Institutional support**
    - Capacity building
    - Quality of technology architecture, systems and design
  - **Outcomes**
    - Innovative professional
    - Productive citizen
    - Critical thinker
- Intends to address
  - Teacher quality
  - Students' learning
- Incorporates how technology integration is measured
  - Engagement
  - Enhancement
  - Extension

3.1.3. The Technology Integration Model is NOT...

- The model does not prescribe how technology is integrated in STEAM education.
- The model does not show the extent of integrating technology inside a STEAM classroom.
- The model does not reflect the current state of technology integration in the Philippine STEAM education, as it merely describes technology integration based on available data.

3.1.4. What is new about the Technology Integration Model?

- The model includes how technology integration is measured.
- It shows how institutional support is placed in technology integration.
- It describes the intention of technology integration and shows the outcomes of technology integration.
- It highlights the role and significance of STEAM teachers in the model as much as their impact on the students.
- It agrees with the PSGs, assists PPST, and strengthens TPCK.

3.1.5. Salient Features of the Technology Integration Model

- The model features the three major variables of technology integration.
- It also shows the processes of each variable essential in integrating technology to achieve quality STEAM education.

- It integrates the Triple E Framework (Engagement, Enhancement and Extension).
- It looks into the alignment to TPACK Framework, PSGs and PPST.
- The outcomes of the model are clearly defined.

3.1.6. What is the Technology Integration Model?

The technology integration model is a framework of how technology integration is reflected to achieve quality STEAM Education. 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*.

The **Teacher technological knowledge (TTK)** refers to the teachers' understanding about technology including familiarity to various technology, understanding how to make and use specific technology in identified lessons, even assess when technology assists or impedes lesson delivery. Teacher technology knowledge has two dimensions: lesson structure and content-driven. The former refers to the integration of technology in specific parts of the lesson, at most, for faster lesson delivery and better presentation, the latter to the use of technology in instruction, specifically applicable to courses on which the content of the course is bound to technology use. Contrastingly, **Institutional Support (IS)** has two dimensions: capacity building and quality of technology, architecture, system and design. *Capacity building* seeks 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, as approximated by the affordability, availability, and appropriacy 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.

3.2. Alignment of the Technology Integration Model to TPACK and Other Theories (PPST and PSG)

The technology integration model agrees with the TPACK model, Philippine Professional Standards for Teachers (PPST), Policy Standard to Enhance Quality Assurance and Policies, Standards and Guidelines (PSG).

3.2. 1. TPACK Model and Technology Integration Model

The core components of teaching with technology are content, pedagogy and technology, and their fusion (Koehler & Mishra, 2009). In the technology integration model, these components were all observed in the theme *teacher technological knowledge* and subthemes *lesson structure* and *content-driven*. In lesson structure, TPCK can be seen in the teaching and learning experience, while TPK focuses on Teacher's understanding of the affordability of Technology. TCK is observed in the laboratory and simulation activities, applicability to the topic and lesson objectives. Single core components TK, CK, PK are shown in teachers' Knowledge on the different types of technology, productive discussions and teaching objectives respectively.

In the variable, institutional support, only TPK, TCK and TK are evident in both *capacity building* and *quality of technology architecture, systems and design* sub-themes. In TCK, the administration supports the training on the effective use of technology inside the classroom. Provision of laboratory room for instruction and research, installation of LCD TVs, or LED TVs, for instruction and setting-up of LMS to aid instruction are evident in TPK. In TK, protocol on the use of laboratory and available technologies are in effect.

3.2.2. PPST and Model in Technology Integration

PPST intends to help teachers reflect and assess their own practices (Department of Education - Teacher Education Council, 2017). The model in technology integration can assist PPST in this aspect. Specifically, the model responds to Domains 1 and 4.

Domain 1 states that skill in the use of technologies is needed to promote high quality learning outcomes. Specifically, strand 1.3 states that there should be a positive use of ICT. In contrast, domain 4 states that teacher should be able to use their professional knowledge and curriculum content to a well -structured and sequenced lessons. Strand 4.5 points out that ICT should be part of the teaching and learning.

In the model, teacher technological knowledge accords with the teachers' need for adequate skills. They should be willing, ready and able to use technology in structuring the lesson, in delivering the subject content, and in evaluating its efficacy. To ensure that teachers meet the skills expected of them, administration supports such by capacity building and providing the technology architecture, systems and design. In terms of the technology to be used, it should be affordable, available and appropriate.

3.2.3. Policy Standard to Enhance Quality Assurance and Model in Technology Integration

Quality assurance provides mechanisms, procedures and processes to get the desired quality. When translated to actions, professional institutions ought to have learning resources and support structures appropriate in developing professional knowledge and skills (CHED, 2012). In the integration model, administrative support is clearly included, with subthemes of providing the technologies and the intricacies of using such technologies.

3.2.4. Policies, Standards and Guidelines (PSG) and Model in Technology Integration

PSG is a program-based quality assurance mechanism set by CHED (Pijano, 2010). A specific PSG is set for every particular program. The model in technology integration agrees with the PSGs inclusion of technology in many aspects. Virtually, it states that general education courses should have basic computer literacy, which is needed in the current technological society (PSGs in Accountancy, Library and Information Science, Nursing, Pharmacy Education & Respiratory Therapy). Learning resources are a must for the delivery of the curriculum (PSGs in Library and Information Science). BESED Math & Computer Engineering in different formats (PSGs in Library and Information Science & Respiratory Therapy). Laboratories, in turn, are indispensable to supplement and complement the attainment of learning outcomes before actual experience (PSG in Library and Information Science, all Science & Engineering programs). These requirements translate to technologies enhancing instruction (PSGs in Nursing & Pharmacy Education) in classroom. That said, in various PSGs, it behooves that STEAM educators possess technological knowledge to effectively deliver the goals stated in the PSGs. At best, the technology may be provided by the administration.

3.3. Purposes of the Technology Integration Model

The technology integration model may address the teacher quality and the students' learning, particularly in the cognitive and affective components. The model intends to provide opportunities for the STEAM educators to update or adapt to new technology used in the classroom and provide opportunities to make STEAM educators highly qualified. Moreover, this will lead to integration of technology in innovative teaching strategy to enhance teaching. Notably, the model outlines the significance of technology integration to produce quality STEAM learners.

In effect, the model attempts to address students' learning. When teachers demonstrate innovative teaching approaches with the integration of technology, students tend to experience meaningful learning evident in a more interactive and effective discussion, which may

gradually lead to improvement of their academic achievement, as they enhance their active participation in the classroom, not discounting their increased motivation and attention span.

3.4. The Model Explained

The Technology Integration Model has three major variables: teacher technological knowledge, institutional support, and the outcomes. Figure 3.1 shows the validated technology integration model.

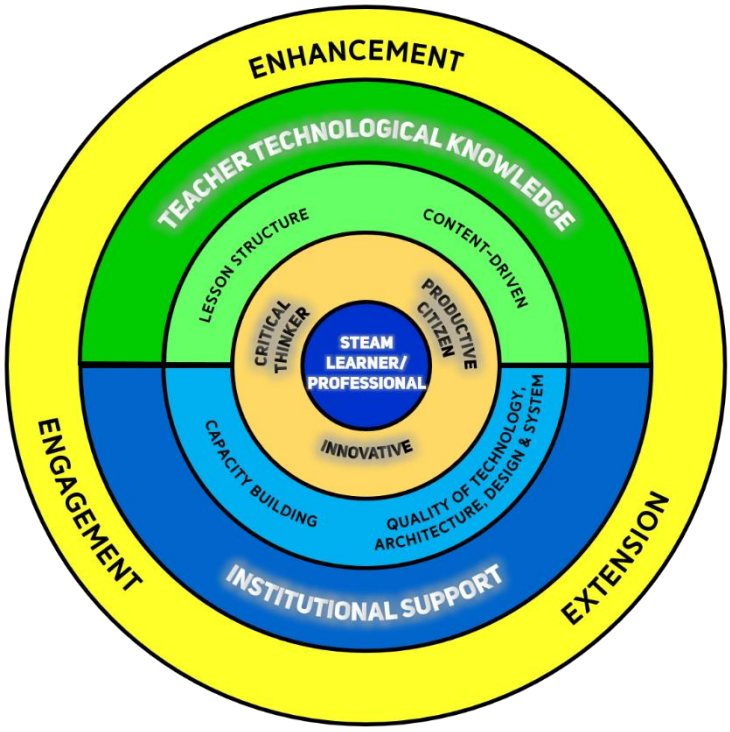

Figure 3.1. Validated technology integration model

Etymologically, the word technology comes from the Greek word *tekhnologia* or systematic treatment of an art or craft, i.e., *tekhne,* skill (American Heritage Dictionary, 1997). "It is the scientific method and material used to achieve a commercial or industrial objective." In the context of the given framework above, technology refers to scientific materials used in support of teaching. This can be classified into analog and digital. Analog technology consists of materials used in teaching that does not require the use of computers, internet, software and the likes. It includes chalkboard, whiteboard, and improvised apparatus or equipment. According to Koehler and Mishra (2009), this type of technology is characterized by specificity, stability, and transparency of function. By contrast, digital technology is protean, unstable and opaque. It includes computers, tablets, SMART board, projectors, PowerPoint or digital slides, clicker response system, movies, software applications, laboratory equipment, and websites.

3.4.1. Teacher Technological Knowledge (TTK) refers to the teachers' understanding about technology, as well as familiarity to various technology, making sense of how to devise and use specific technology to identified lessons, and how to assess when technology assists or impedes lesson delivery (Koehler & Mishra, 2009). Essentially, teachers with technological knowledge should know their basic intentions in using or integrating these technologies, or in considering the choice of a specific technology and when and what part of the lesson technology is used. In this regard, the National Research Council (NRC, 1999) coined the term Fluency of Information Technology (FITness) that goes beyond were technological literacy, requiring an adequate grasp of the best technology to be used in achieving set goals and objectives.

Lesson Structure means the integration of technology in specific parts of the lesson, at most, for faster lesson delivery and better presentation. Primarily, it enhances the learning experience of students by increasing their interest in the lesson using technology that is otherwise impossible or time-consuming when done manually. *Content-Driven* is the use of technology in instruction and only applicable for specific courses where the content of the course is bound to technology use. This aspect may include Information Technology subjects, subjects with laboratory and practical works among others.

Teacher knowledge of technology either for lesson delivery or as required by the course content must be engaging, enhancing, and extending to maximize the teaching and learning experience.

3.4.2. Institutional Support (IS) refers to the assistance and other forms of support given by the institutions and its administration. It has two dimensions: capacity building and quality of technology, architecture, design and system.

Capacity building means the act enhancing 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 systems* refers to various software, applications, devices and other instruments that the teachers need to carry out the teaching-learning process. This scope can be approximated by the affordability, availability and appropriacy of the technology used in instruction and/or assessment and design of the school. Technology that is available in schools for teaching and learning are greatly affected by how much the technology costs and the institution's financial capacity. Such demands for software and subscriptions need budgetary allotment from the institution. In other instance, availability of technology is another consideration, it being connected to affordability some schools fall short of funds with which to operate. Appropriacy bespeaks the teacher's choice of technology to enhance the teaching of specific topics, as affected by

what technology is readily available for teachers to choose from which, in turn, is affected by technology affordability.

Current and modern designs to assure the comfortable use of technology in teaching and learning are called for to produce *critical thinkers*, *productive citizens* and *innovative STEAM professionals* in promoting quality STEAM education.

The technology integration model theorizes using the TPACK, SAMR and Triple E framework with emphasis on Triple E: *engagement, enhancement, and extension*. The model shows no barriers enough to 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 the choice of tools to meet the learning goals, and design learning episodes using tools that impact students to deduce the desired learning outcome.

The technology integration model underwent two-tier validation process that revealed the existence of some emerging concepts considered part and parcel of the model. These concepts somehow may reflect the current and future technology integration model. Figure 3.2 presents the emerging technology integration model

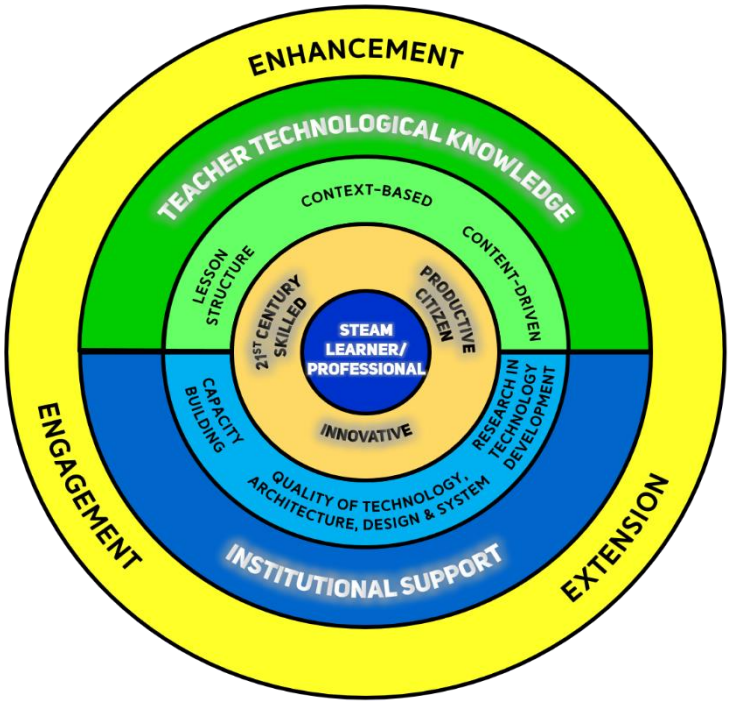

Figure 3.2. Emerging technology integration model

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 an additional dimension each falling 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 and the students. Under institutional support the added dimension refers to research in technology development that creates opportunities to innovate and develop technology related to STEAM disciplines. The utmost outcomes of being a STEAM learner/profession is to possess *21st century skills* that could help learners thrive well in a competitive, highly technological world.

3.4.3. Domain Overview

3.4.3.a. Teacher technological knowledge (TTK)

Teacher technological knowledge (TTK) refers to the understanding of teachers about technology. This aspect includes familiarity to various technology, understanding how to make and use specific technology to identified lessons, and how to assess when technology assists or impedes lesson delivery. Under the validated technology integration model, TTK has two dimensions: lesson structure and content-driven while in the emerging technology integration model, context-based is an added dimension.

3.4.3.b. Institutional Support (IS)

Institutional support refers to the assistance and other forms of support given by the institution and administration. Under the validated technology integration model, IS has two dimensions: Capacity building and quality of technology, architecture, design and system, while in the merging technology integration model, research in technology development is an added dimension.

3.4.3.c. Outcomes

Outcome is the third variable in the technology integration model. The model attempts to produce quality STEAM learners and professionals who are critical thinker, productive citizen and innovative. On the other hand, the emerging model includes possessing 21st Century skills as one outcome in producing quality STEAM learners and professionals.

3.4.4. Illustration of Practice

Table 3.1 shows the technology integration practices of the STEAM teachers grouped according to their respective STEAM disciplines.

Table 3.1. Technology integration practices among the STEAM teachers

STEAM	Technology Integration Practices	SAMR (Substitute, Augment, Modify, Redefine)	Triple E (E1-Engage, E2-Enhance, E3-Extend)	TPACK (TK, PK, CK, TCK, TPK, PCK, TPCK)

Science	Use of PowerPoint presentation in presenting and delivering the lesson.	S	E1	TPCK
	Models of a cell, other improvised models are used to enhance learning.	A	E2	TPCK
	Use of PowerPoint in presenting and delivering the lesson.	A	E1	TPK
	Use laptops, computers, speakers, LCD projector as an aid in teaching.	A	E1	TK
	Use flash, clicker response, android dictionary and computer software to deliver a lesson.	A	E3	TPCK
	Blended learning and computer-aided learning are used to augment learning.	A	E1	TK
	Technology is integrated with the use of PowerPoint, flash, videos, models, internet and the use of technology tools such as whiteboard, LCD projector, and computer software to delivering lessons.	M	E3	TPCK
	These technology tools are used as part of the teachers' pedagogical practices such as content-based instruction, lecture, laboratory and to integrate to other disciplines.			
Technology	Use animation with integration to other disciplines.	R	E3	TPCK
	Aided with simulation and computer graphics and computer software to enhance learning activity.	A	E1	TCK
	Read online materials	A	E1	TCK
	Integrate human anatomy in teaching body animation.	R	E2	TPCK
	Aided with Use simulation and computer graphics and computer software.	A	E1	TCK
	Use of PowerPoint in presenting and delivering the lesson.	A	E1	TPK
	Use laptops, computers, speakers, LCD projector, smart TV as an aid in teaching.	S	E1	TK
	Immediate feedbacks with the use of computer.	A	E2	TPK
	Hands-on with computer activities.	A	E2	TPCK
	Technology is integrated with the use of PowerPoint, flash, videos, models, internet and the use of technology tools such as whiteboard, LCD projector, computer software to delivering lessons.	A	E1	TPK

Engineering	Integration of Galton Board.	M	E2	TPCK
	Use visualization like graph/dot matrix.	S	E2	TPK
		A	E1	TPK
	Use laptops, computers, speakers, LCD projector as an aid in teaching.	A	E1	TPK
	Use of PowerPoint in presenting and delivering the lesson.	A	E2	TPK
	Equipment and tools are used to enhance lesson delivery.	A	E2	TPK
	Technology integrated activities like a strategy game, graph activities interactive video are used.	A	E1	TPK
	Lecture-discussion coupled with PowerPoint, video.			
Agri-Fisheries	Use PowerPoint (computer aided learning) **but limits teacher's interaction with* students.	A	E1	TPK
	Use of PowerPoint in presenting and delivering the lesson.	A	E1	TPK
	Teaching lesson is aided with a PowerPoint.	A	E1	TPK
Mathematics	Use flash quiz.	A	E2	TK
	Use excel in solving matrices/linear problems.	S	E2	TCK
	Use computer-aided learning	A	E2	TK
	Software like SPSS is used.	S	E2	TK
	Visualization of graph function.	S	E2	TK
	Use laptops, computers, speakers, LCD projector as an aid in teaching.	A	E1	TPK
		A	E1	TPK
	Teaching tools such as whiteboard, PowerPoint, videos, LCD projector, calculators, computers.	R	E3	TPCK
	Integration of the topic to the real-world and to other related disciplines using technology integration.			

Table 3.1 shows the technology integration practices of the STEAM teachers when grouped according to their respective disciplines of specialization. These practices were coded based on classroom observation notes, interview transcripts and teachers' responses to the open-ended questions in the survey. Using SAMR framework, augmentation is found to exhibit in the technology practices demonstrated among the STEAM teachers. In augmentation, teachers often use technology as a direct tool substitute with functional improvement to enhance learning, and the least goes to modification, which would allow use of technology for significant task redesign to configure learning transformation (Microsoft Asia News Center, 2018). This phase is followed by substitution in which technology acts as a direct tool substitute without functional change (Microsoft Asia News Center, 2018). As per STEAM discipline, the most number of practices is in Technology and the least in Agri/Fisheries. Various technology integration practices based on SAMR in all STEAM disciplines except in Agri/Fisheries

dominate augmentation level. Seemingly, STEAM teachers exhibit a vision for higher level of technology integration to provide transformational atmosphere of learning to bring the Filipino learners to a level of self-directed learning (Heick, 2018) which the students need in this era.

Triple E framework provides the model for educators to measure how well technology tools integrated into lessons are helping students to meet the learning goals (Triple E Framework, .n.d.). The framework is based on three components: Engagement, Enhancement, and Extension. In terms of Triple E framework, the majority of the technology integration practices exhibited by the STEAM teachers show engagement in learning in which these technology integration practices allow the students to focus on the learning activity and motivate learning. Some technology integration practices are observed to enhance learning goals, as particularly observed in Engineering, Technology and Mathematics disciplines. Additionally, technology integration intends to reinforce the STEAM teachers' pedagogical practices by integrating technology on the common teaching methods such as lecture-discussion, laboratory, and inquiry-based approach, among others. In the Science discipline, notably technology integration is practiced to extend students' learning to other disciplines. The results may give STEAM teachers insights into advancing or furthering the integration of technology to increase students' engagement in learning, better yet, enhance and extend learning to connect and apply to the real world.

The technology integration practices of the STEAM teachers are also described using the TPACK framework that mostly concentrated on TPK, TK, and TPCK among all the the dimensions of TPACK framework. Considering that STEAM teachers are disciplined-based professionals all experts in their respective disciplines—they use technology as part of their pedagogical approach in the delivery and presentation of their STEAM lessons. Meanwhile, TCK is the least identified dimension in the technology integration practices of the STEAM teachers. This finding may mean that discipline-based is a basic consideration in integrating technology and that content knowledge influences the development of TPCK (Cetin-Berber & Erdem, 2015). Among the STEAM disciplines, science teachers seem to have more TPCK practices in their technology integration while all other disciplines are taking their skills to integrate technology further enough to prompt them to enhance their professional development to further explore technology integration as part of their pedagogical practices.

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