www.ijres.net

Teacher Professional Development Program (TPDP) for Teacher Quality in STEAM Education

Marie Paz E. Morales
Philippine Normal University, Philippines

Felixberto M. Mercado
Manuel S. Enverga University Foundation, Philippines

Caesar P. Palisoc
Philippine Normal University, Philippines

Brando C. Palomar
Philippine Normal University, Philippines

Ruel A. Avilla
Philippine Normal University, Philippines

Celina P. Sarmiento
Philippine Normal University, Philippines

Benilda R. Butron
Philippine Normal University, Philippines

Thaddeus Owen D. Ayuste
Philippine Normal University, Philippines

To cite this article:

Morales, M. P. E., Mercado, F. M., Palisoc, C. P., Palomar, B. C., Avilla, R. A., Sarmiento, C. P., Butron, B. R., & Ayuste, T. O. D. (2021). Teacher professional development program (TPDP) for teacher quality in STEAM education. *International Journal of Research in Education and Science (IJRES), 7*(1), 188-206. https://doi.org/10.46328/ijres.1439

IJRES International Journal of Research in Education and Science
2021, Vol. 7, No. 1, 188-206 https://doi.org/10.46328/ijres.1439

Teacher Professional Development Program (TPDP) for Teacher Quality in STEAM Education

Marie Paz E. Morales, Felixberto M. Mercado, Caesar P. Palisoc, Brando C. Palomar, Ruel A. Avilla, Celina P. Sarmiento, Benilda R. Butron, Thaddeus Owen D. Ayuste

Article Info

Article History

Received:
25 May 2020
Accepted:
05 November 2020

Keywords

Lesson exemplar
Peer review
Panel critiquing
PSE model
STEAM teachers
Teacher professional development program

Abstract

The study implemented and evaluated a TPDP for the sampled 106 STEAM (science, technology, engineering, agri-fisheries, mathematics) teachers. The study used participatory action research (PAR) as a methodological framework. Results reveal that in all phases of the TPDP, three key points emerged: power, product and process. Power emphasized equitable participation dislodging imbalance of power, while process highlighted PAR cycle: planning, acting, reflecting and discussing. Finally, the product: co-learners, and emancipated participants who co-developed lesson exemplars in STEAM. Results further reveal that the participants successfully crafted Lesson Exemplars in their chosen STEAM topic exemplifying the principles of TPCK (technological, pedagogical, content knowledge). Pilot tests (using Action Research) show how the STEAM teachers highly engaged the learners. As TPDP, PAR may achieve teacher quality and quality STEAM education in the country and may adapt micro-credentialing to fully structuralize capability building programs.

Introduction

A majority of first world countries believe that investment in human capital is beneficial for economic and knowledge growth and development. They adhere to the concept that a STEAM workforce plays a meaningful role in propelling economies by meeting the demands of the 21st century job market to potentially reduce unemployment rate (Fiddis, 2017). In essence, STEAM education careers bridge the prospects of STEAM human capital and economic growth, international competitiveness, and the job creation of most developed countries (Zenobia, 2018). However, although the ASEAN claims parallel footing for both developed and developing countries, most literature do not specify the same benefits of STEAM education in the latter due to technological incapacities (Zenobia, 2018).

Yet, what the world has seen brings all nations to underscore STEAM in the existence of humanity. Natural disasters and pandemic (e.g., COVID-19) do not distinguish how economically advanced a country is. The current health crisis of this magnitude requires the expertise of STEAM professionals (Seale, 2020), and everyone"s skills, and mindset to afford security and sustainability to humanity in general, without reference to a country"s economic status. STEAM skills have become a necessity, and STEAM education have to contribute to

informal and domestic works by enhancing hygiene and health (Tikly et al., 2018) to prepare humanity for worse scenarios. This brings STEAM education to the forefront in all countries (Ohize, 2017). Such an education framework – one that works within the bounds of Education 4.0 – necessitates quality STEAM teachers to help build STEAM-skilled citizens who are upskilled, reskilled and cross-skilled to enact STEAM curricula for global and societal needs. Thus, this study focuses on building quality STEAM teachers through a TPDP, grounded on the TPCK framework in Philippine STEAM education, and PAR as methodical structure.

From STEM to STEAM

As a global icon, STEM progressed as a framework in educating the future human capital. Believing in the idea that „disciplines are stronger together than they are apart", first world countries teamed STEM with an "A" for the Arts forming a new alliance of discipline that may be able to develop skills that students will eventually use in the workplace (e.g., ability to work with others, verbal communication, creative and critical thinking, disposition towards lifelong learning) (Infosys, 2016). These capabilities and visions of STEAM as an education framework provide a complete picture of STEAM professionals as demanded by Seale (2020) to successfully thrive in a technology-driven society, and to be able to sustain humanity amidst natural calamities and grave health risks/crises.

The Philippine higher education (HE), staged STEAM emphasizing "A" as agri-fisheries courses (Commission on Higher Education, 2015). This move was dictated by the fact that agri-fisheries play a significant role in the country"s economy, where 40% of agricultural workers contribute to an average of 20% to the GDP (Monde, 2019). However, HE data (Commission on Higher Education, 2019) registered only 11.6% of schools (Higher Education Institutions [HEIs]) offering agricultural programs. Entrants only averaged 3.3% of the total in all HEIs, and only 3.5% complete their agricultural degrees. This country situation pushed for adopting agri-fisheries for the "A" in STEAM as a bold move of the government to improve and develop the backbone of the Philippine economy (Monde, 2019).

TPDP for STEAM Teacher Quality

Building quality teachers may require teacher professional development programs (TPDP) as one venue for teacher transition and transformation. There are numerous types of TPDPs and those labelled as transformative models (use of Action Research [AR] and a combination of other models) (Kennedy, 2014) exude the components of effective TPDPs such as: content focus, active learning, coherence, sufficient duration and collective participation (Darling-Hammond et al., 2017). Such may develop in the STEAM teachers" reflective-practice and reflexivity as well. Within the AR tradition, PAR is seen to benefit the education field by fostering collaborative characteristics of AR. In participation with others, it seeks to bring together action and reflection, and theory and practice, specifically in pursuit of practical solutions to issues of pressing concern to people, and more generally, to the flourishing of the individual and their communities (Reason & Bradbury-Huang, 2001). Apparently, PAR may suit well the premises of a transformative model of TPDP which this study highlights.

Framework for TPDP

PAR works to describe and understand the human experience and the meanings ascribed to them. As a subset of AR, PAR focuses on the "systematic collection and analysis of data for the purpose of taking action and making change by generating practical knowledge" (Gillis & Jackson, 2002, p. 264). The philosophical underpinning of PAR emphasizes the non-linearity of the contexts of people‟s lives (Chandler & Torbert, 2003), while traversing the cyclic processes of plan, act, reflect (Kemmis & McTaggart, 2000, p.595). As a methodological framework, PAR aims to reduce power imbalance, promote social justice and transformative changes, and engage participants in empowerment, community integration, professional accountability and identity formation. In higher education, AR has advanced to pervade the pedagogical and curriculum theory (Gibbs et al., 2017). With its emancipatory core and multi-disciplinary flexibility (Gibbs et al., 2017), PAR processes include the participants' voice and active involvement, that speaks more on the inclusive nature of (educational) research, for personal and structural transformations of educational environment (James, et al., 2008 as cited by Walker & Loots, 2018).

In its current state, training and professional development of Philippine STEAM teachers (tertiary level) focus on research and other related activities as the majority of them are discipline-based and content-oriented. They attend research conferences and workshops, which abound in the country and abroad as their professional development (PDs), but they exhibit low engagement in skills training related to pedagogy, assessment, and other education related workshops. Such low engagement to teaching-related trainings hamper their improvement in these aspects of tertiary teaching. In fact, the quality of instruction in Philippine tertiary education is rated very low by the Asian Development Bank (The Report: Philippines, 2017). This state may mean and call for a re-route of trainings to improve and update their knowledge, skills, and competence related to the practice of teaching, spelt out as technological, pedagogical, and content knowledge (TPCK), which the current study highlights.

PAR was chosen as an approach to TPDP (in higher education) in this study to embody collaboration and equitable partnership among the sampled STEAM teachers. The study intended to capitalize on the learning experiences and reflections of the participants throughout the study (TPDP design and implementation), enabling them to develop professional and public accountability as part of the outcomes of observing and practicing PAR in HE. Furthermore, the study grounds on the theoretical underpinnings (TPCK framework, and STEAM tertiary teaching standards) of the entire project (entitled, TPACK in Philippine STEAM education) to which this study form part of (Morales et al., 2019). The research team hopes to provide significant improvement in STEAM education through a TPDP that feature empowerment, co-learning, capacity building and system change, and a balance of research and action working towards progressive education.

Purposes of the Research

The study implemented a TPDP for Philippine Higher Education (PHE) STEAM teachers using PAR as the methodical framework in developing Lesson Exemplars (LEs). Specifically, the study sought to:

1. Describe the implementation of TPDP for PHE STEAM teachers focused on:
    1.1. Development of LEs
    1.2. Validation of LEs
2. Evaluate the implementation of the TPDP for STEAM teachers.

Method

Research Design

The Philippine HE categorizes schools as teaching universities and research universities. The latter are customarily known to be superior in all the key results areas: 1) quality and relevance of instruction; 2) research capability and output; 3) services to the community; and 4) management of resources. The inferior status of teaching universities and the insistence of the higher education system to capacitate teachers in all universities in research bring teachers from these universities at a disadvantage. Specifically, teachers‟ need for pedagogical content knowledge is in tension with the desire of the state to upskill all STEAM professionals in research and innovation. Likewise, it is a common observation that STEAM professionals who land into teaching in HE lacks skills in enacting the STEAM curricula. These contexts motivated the use of PAR in the implementation of a TPDP (Somekh & Zeichner, 2009) for the sampled STEAM teachers. PAR was thought to be a useful methodical framework to deduce their experiences as inputs to the Philippine STEAM education model (PSEM), and make use of their consensus reflections and insights in developing their LEs, and in assessing how efficient and effective their developed LEs are in engaging students when enacting STEAM lessons.

Participants

This study presents two groups of participants, but only highlights the last group (see Table 1 for their corresponding roles).

Table 1. Roles, Responsibilities and Expectations

Group	Participants	Roles, Responsibilities and Expectations
PAR-Group1 (Researcher-led)	Principal Investigator, Lead Researchers	Project conceptualization for funding, initial inputs to project to draft the PSEM, initial inputs to guide to crafting lesson exemplars
PAR-Group 2	University researchers, volunteer graduate students, and selected 106 teachers of STEAM disciplines in the Philippine Higher Education	Group discussion on inputs to the PSE Model, discussion on the crafting of lesson exemplars in their identified topic (the topic was a consensus by the group), critiquing, presentation and finalization of the Lesson Exemplars Implementation of Action Research in their home university, consultation with any member of PAR-Group 1, presentation of AR results to the entire group in a formal forum

The researcher-led group (Hand et al., 2019) initiated the project (per requirement by the funding agency). This group conceptualized and facilitated the entire scope of the project including the development of PSEM, which were reported in other articles. The focus participants of the study are the purposely selected 106 teachers (PAR-Group 2) clustered according to their disciplines such as: Physical Sciences (25); Biological Sciences and Agri/Fisheries, (33); Technology and Engineering, (21); and Mathematics (27).

Each cluster made a consensus on selecting one teacher who will be conducting action research in implementing and documenting the designed lesson exemplar (Kemmis, 2006). For compliance with all ethical considerations, the research team sought ethical approval from the University ethics committee before the conduct of the entire government-funded research. Informed consent from all participants was also sought, and the team observed all ethical considerations (e.g., disclosure, anonymity).

Instruments

LE Instructional Design and Template

This instrument includes: subject or course details, learning outcomes, target audience, pedagogies (lesson introduction, lesson activities, assignment), efficient classroom management, misconceptions to address, integrating technologies, lesson strategies, technology being used, limitations of technology, required materials, assessment and feedback strategy, reflection, modification, and feedback.

Rubric for LE

The rubric for LE describes all attributes (six criteria) of a LE: connection among content, pedagogical approach and technology, rationale for instructional strategy/-ies, appropriateness of technology for instructor use, alignment to state standards for content and competencies, completeness, and language and mechanics. The rubric follows a four-point rating scale for the performance level, and the indicator per criteria-rating pair. The developed rubric underwent content validation by invited STEAM education experts.

LE Peer Review Form

This form (presented in tabular format) features the expected attributes (about 2 to 3 attributes, clustered into the seven TPACK dimensions) of the developed LE. The five-point performance level ranges from „exceeds standards“ (5 points) to „no evidence“ (1 point), with an included column for remarks and suggestions of the peer reviewer.

TPDP Evaluation Form

This instrument includes 18 major items, in combination with Likert scale items and open-ended questions. The first seven items focused on the agreement of participants on statements about the objectives of the TPDP. Items

8, 9, and 10 emphasize ratings for the TPDP, and the last sets of items are open-ended questions and points for reflection.

Study Context

This study anchors on a government-funded research that aimed to empower the sampled STEAM teachers (of teaching universities in the country with minimal training on pedagogy, assessment and technology integration in education) in enacting their respective programs and courses in HE. The methodical framework of the current study grounds on PAR, but phases are sequential in nature. A meaningful engagement of the participants happened in separate events: crafting of the LEs in the different STEAM disciplines (through a capacity building program), implementing the developed LEs, and presentation and reflection in a country-wide forum. LEs are representative model of a lesson. Appendix-Table 1 (available at http://pnu-onlinecommons.org/omp/index.php/chedpnutpack/catalog/book/1104) presents all information on instruments, participants, detailed data collection (with a well-represented PAR cycle of planning, observing/acting, reflecting and discussing in each phase), and data analysis for the entire study. The table also included description of prior processes for holistic understanding.

Data Collection

Phase 1and 2: TPDP Baseline Data and TPDP Design

Phase 1 (as a priori) generated the baseline data of the project that includes STEAM teaching proficiency in terms of TPCK framework, Philippine tertiary teaching standards (Morales et al., 2019), and developed a model (Philippine STEAM model [PSEM]) of how STEAM teachers in the Philippines enacted their respective disciplines. The details of documentation of these phases (also briefly presented in Appendix-Table 1) are reported in Morales et al. (2020). The PSEM influenced the design and implementation of the TPDP using the PAR framework. The first two phases which involved PAR-Group 1 developed all instruments and indicators utilized in the conduct of the study.

Phase 3: Lesson Exemplar (LE) Development through Capability Building Program (CPB)

The implementation of the TPDP focused on the collaborative development of LEs by all the participants commenced on March 19 and culminated on March 21, 2019. Within the TPDP implementation, PAR-Group 1 presented to the entire group of participants all products of the aforementioned first two phases. Within the clusters, planning commenced with brainstorming of the common topic for the LE development, and the different school context they have. Reflexive action within the group was done every now and then, enabling the group to provide inputs on the instruments for improvement before commencing the development process of LE. After almost a day of planning and development, self-assessment (using the rubric) was done through cluster critiquing facilitated by their appointed representative. These self-assessments were validated through peer review (using the peer review form). Finally, each cluster did reflexive actions and reflections on all comments and suggestions, and integrated them in the final LEs. The final LEs were shared to the entire group

of participants through panel presentation, and suggestions were further collected by the cluster for another round of reflections and discussion within the cluster to finalize the LE.

Phase 4 and 5: Lesson Exemplar Implementation and Presentation in a Country-wide Forum, and TPDP Evaluation

This phase commenced with cluster planning on how the LE will be implemented as an AR. Each cluster conceded to have one representative to implement the LE as an AR in his/her home institution. The implementation of LE through an AR was limited to a month (due to deadlines and schedules with the funding agency). Since all representatives per cluster are based in the provinces or rural areas (and with limited funds), consultations and discussion with other participants were only done via online systems. The representatives of the clusters who implemented the AR documented the process through video and audio recordings, but only reported still photos as per request of their students (use of photovoice instead). Cluster reflection was done on the first day of the country-wide forum held on April 25 and 26, 2019. Finally, discussion was conducted in this phase through sharing of the LE implementation results of the four representatives.

For the evaluation phase, PAR-Group 1 included a Q&A portion every after session aside from the 4-point scale evaluation instrument administered to all participants. More time was also spent on sharing after every AR presentation. Moreover, the open-ended questions initiated self-reflection on the part of each participant. Finally, impressions shared by the representatives of the clusters were also presented which emphasized the collective reflections of the cluster on the TPDP.

Data Analysis

Different qualitative and quantitative data analysis tools were utilized in the different phases of the study. Sequential analysis of the products of this study was used to inform the development and validation of the final lesson exemplars. Coding, photovoice and content analysis of peer reviews, transcriptions of panel presentation and critiquing, and pilot study of the LEs were likewise implemented.

Results and Discussion

TPDP Baseline Data (The Philippine Higher STEAM Education Model) and TPDP Design

Meetings and discussions initiated by PAR-Group1 for the conceptualization, implementation, monitoring and evaluation of the entire project opened communicative spaces (Morales, 2016) leading to a consensus of "*what we should do, what we did, what are the implications of what we have done.*" In this study (as part of the entire research project entitled, TPACK in Philippine STEAM education), PAR-Group1 initiated meaningful dialogues and discussions with the purposely selected (106) STEAM teachers to confirm and attest the altruistic character of the PSEM (see Figure 1) that dictated the design of the TPDP.

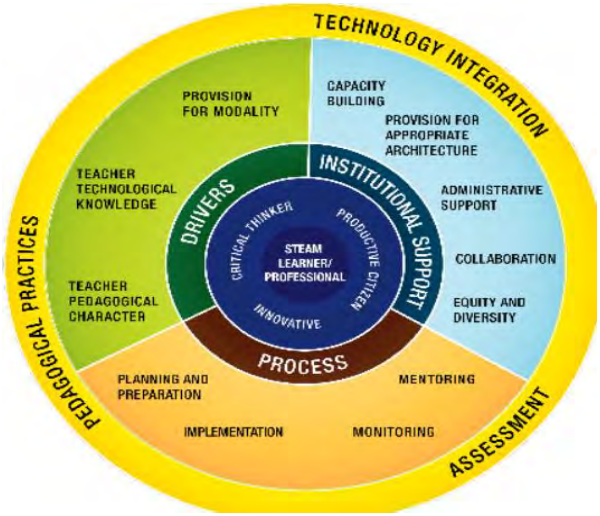

Figure 1. The Validated PHSE Model (Morales et al., 2019, p. 82)

The designed TPDP has three parts. Parts 1 and 3 are conventions where all the participants come together to co-learn, co-discuss, co-develop, co-critique, and co-reflect (Kelly, 2005; Sato, 2012). Part 2 is a month-long guided implementation of LE developed in Part 1. In the implementation of LEs, each member has a different concern and expected individual commitment; but is part of the team in managing conflict resolutions and building relationships.

Lesson Exemplar Development through Capability Building Program

The implemented TPDP grounds on theories such as participatory action, and experiential and active learning. Being participatory in nature, the TPDP may be considered as a transformative model of professional development (Kennedy, 2014) that underscores the components of effective professional development programs such as: content focus, active learning, coherence, sufficient durations and collective participation (Darling-Hammond et al., 2017). LE development involved the principles of content focus, active learning, coherence, and collective participation. LEs developed per cluster feature the expertise of the cluster. As each of them contributes to the design of LEs within their clusters, thus active learning process may have fairly and coherently taken place (see Figure 2).

The participatory nature of the dialogue on PSEM involving the participants induce a feeling of belongingness and ownership of the model for them to properly and easily concretize its intentions in the LEs. This sense of belongingness may have triggered the participants to do and bring out their best during the TPDP and eventually owning the product as their best (PSEM). The experiential learning simulated in the development of LEs within the TPDP made them immediately see connections of the model (PSEM) to their line of work, which may have provided them meaningful learning. This meaningful learning that emanates during the LE development part of the TPDP may be brought about by the characteristics of the TPDP which resembles experiential learning (e.g., engaging, personal, community-connected, integrated and builds successful skills) (Ark & Meyers, 2018).

Figure 2. (a) Technology and Engineering Cluster; (b) Mathematics Cluster; (c) Science (Biology and Agri-Fisheries) Cluster (d) Science (Physics and Chemistry) Cluster

The completed LEs by and per cluster are indicative of the partial success of the TPDP in engaging them to be lesson designers as well as researchers with the core intentions of improving STEAM learning, partially making them reflective-practitioners (Morales, 2016). In details, the smaller groups‟ LEs are within the topics as per consensus of the cluster: physical sciences–*Laws on Thermodynamics (5 LEs)*; biological sciences and agri/fisheries–*Different Muscle Types (7 LEs)*; technology and engineering-*Binary Number System Conversions (4 LEs)*; and Mathematics–*Fibonacci Sequence (6 LEs).* Their skill in deducing the appropriate and specific learning objectives from the broadly stated learning outcomes manifests that they are able to distinctly distinguish one from the other exemplifying their proficiency (DePaul, 2019). The way they identify appropriate teaching strategies, assessment, tools and technology based on the conditions of their learning environment, availability of materials and nature of learners support exhibited their understanding of the PSEM‟s intention of empowering them to be curriculum planners. The researchers also noted how the participants dedicatedly attribute their designed LEs to the specific features of the PSEM (Table 1). In fact, being reflective in all aspects and parts of the LE showcase how this part of the TPDP manages to develop reflective STEAM teachers (Morales et al., 2020).

Further observations reveal that the crafted LEs show how teachers build the STEAM concepts or disciplines from varied scaffolding learning activities (Sarikas, 2020), which were seamlessly interwoven to provide a robust understanding of the lesson. For example, teachers in the biological and agri-fisheries use video presentations in the lesson on muscle types, followed by a technology-enhanced lecture, and a pre-laboratory orientation. Their lesson design includes the appropriate sequence for laboratory activity proper with a post-laboratory discussion and assessment using short exam and practical examination after the conduct of laboratory activities, born about by the discussions and reflections within the cluster. They consider "*power interruption and possible students' difficulty of properly using technology and equipment,"* and *"technological incompetence and ineffective time management"* as some possible limitations as well. As part of their assessment strategies, they consider the written laboratory report and group evaluation on the conduct of the activity as good sources of student data. As such, all sequence of processes spelt in the LEs define the three

major processes of scaffolding learning to learners: *contingent* through technology aids (responsiveness, tailored, adjusted, differentiated, titrated, or calibrated support), *fading* through group activities (the gradual withdrawal of the scaffolding), and the *transfer* of technology through peer teaching and individual assessment (responsibility for the performance of a task is gradually transferred to the learner) (Van de Pol et al., 2010). Designed LEs feature a section for teachers‟ reflection for them to contemplate on the teaching and learning processes of a STEAM lesson. Consequently, this section of LEs instinctively inculcate and develop engagement to reflective actions showcasing how the teachers are able to develop a habit of the mind and a culture of reflection-on-action (Morales, 2016; Schon, 1984).

Table 2. LE Attributes Anchored on STEAM Teachers Improving their Visual Representation of the Condition of STEAM Education in the Country

Attributes/Features	**Contextualization in Lesson Exemplar by the STEAM Teachers**
Teacher Pedagogical Character and Provision for Modality	Capability of STEAM teachers to develop their learning outcomes, unpacking these outcomes into specific lesson objectives, and identifying appropriate teaching strategies, assessment, tools and technology based on condition of their learning environment, availability of materials and nature of learners
	Building of the concept from varied and scaffolding learning activities
Teacher Technological Knowledge	Use of available and appropriate technological tools
Equity and diversity form of Institutional Support of the PSE Model	Descriptions of learners in the lesson exemplars
Assessment	Formative, and summative, reflection Use of Technology in assessment

Multiple and shared realities extend from the conception of LEs to self-assessment, and validation processes (e.g., peer evaluation, panel critiquing). The entire co-development processes highlight multiple sharing (Kelly, 2005) and a balance of power (Gibbs et al., 2017) that spurred insights and reflections focused on three key points (as per coding analysis): 1) strengths of the orientation and training on LE development; 2) contribution of the TPDP and LE development on their professional growth; and 3) the least of their expectations. Although they find the entire TPDP (specifically LE development) as engaging and important to their professional growth, they (per cluster) encountered multiple tensions in the co-development process. But they claimed that through intensive discussions and reflections, they were able to co-develop their LEs ascribed to how they intend to improve their current visual representation of STEAM education (see Figure 1).

Lesson Exemplar Implementation and Presentation in a Country-wide Forum

Per consensus of the participants in each of the clusters for this phase, implementing their designed LEs will be a good validation of the LEs. They unanimously agree to use AR in the implementation in the belief that AR "*addresses the concern of merging practice and research together*," "*occurs in naturalistic settings and within the context of the STEAM teachers*," and "*empowers them not just as a practitioner but also as a researcher*," Hereon, PAR cycle re-activates, and planning commences per cluster. Each cluster conceded to have one representative to implement the LE as an AR in his/her home institution. Planning sessions were extended online due to distance between the locations of the cluster members, and funding resources of the study. These sessions consequently deduced improved LEs contextualized according to the pervasive problems within the implementers‟ class. Note that low student engagement is common to all the four implementers of LEs, thus it was considered as an issue for action.

Using photovoice technique, the implementers captured all significant episodes in the videotaped lesson implementation of the clusters to showcase the learners‟ reception of the designed lessons (see Figure 3). Reflections commenced via online and face-to-face, and on the first day of the National Forum (conducted on April 25-26, 2019). Each of the clusters‟ analyses describe the improvement in student engagement (students volunteer to do board work, collaborative attitude is manifested during group activities, they express themselves and they participate actively in recitation or discussion), which are all indicators of high student engagement (Johnson, 2012). Teacher-implementers confirm all these analyses, "*mas active sila sa class (they are more active and [participative] in class),*" "*gusto nila yung may game (they like games) and they feel happy inside the class*", "*they volunteer to recite, which is new considering they are college students not high schoolers,*" which may be indicative of meaningful lessons (Pino-James, 2014).

Figure 3. Excerpts of Captured Moments from Video Records of the Pilot Run of the LEs per Cluster

Sharing the results of the cluster analyses and reflections to the entire group highlights the second day of the national forum. The implementers took turns in the sharing session, which initiated discussion of the entire group. Per discussions, they appreciate that they were able to "*test and adjust the exemplar to their own context and respective teaching goals*." Partly, they insightfully share their full engagement in the AR process and successfully assumed the roles of a practitioner and a researcher, with the help and guidance of their cluster. Discussion of the entire group affirmed that their LEs have "*attainable objectives set*," "*has a logical sequence*," "*can be completed with the suggested pedagogy*," "*encourages the use of available technologies*," "*includes a sound assessment process*," and is an "*effective instructional plan for STEAM students*," thus substantiating the validity of the LEs (Tummons, 2010).

TPDP Evaluation

Reflexive actions, reflections and communicative spaces were sustained even in the evaluation of the TPDP although there was a summative evaluation of the program. Minute evaluations (labeled as dialogues) were done every after a session in the TPDP to provide inputs for reflections and questions for clarifications. In general, the larger group of teachers believed that the PSEM (see Figure 1) captured their current condition in teaching STEAM discipline, and also depicted their common vision and aspiration for the improvement of STEAM education. One reflected, "*if the goal is to develop STEAM-skilled Filipinos, then the target goal should be in the core of the visual*." Another communicated his reflexive action by underscoring that, "*the dialogues did not just make them reflect on what they can extract from the TPDP, but what they might contribute as well*." The TPDP had several of these dialogues during the implementation phase. Most of such dialogues are points for reflection in co-development of LEs. Table 2 presents the feedback and reflection of the participants for the entire CBP that highlight the development of LEs.

Table 2. STEAM Teachers" Assessment and Reflections

Points for Reflections	**Participants' Reflections and Insights**
Most suggested strengths or positive viewpoints of training and orientation (CBP)	• Relevant workshops *(48)* • Clear presentation of STEAM models *(43)* • Opportunity for collaboration *(19)* • Gaining/learning new information *(13)* • Smooth conduct of event *(10)*
Contribution of the training and orientation (CBP) and LE development on STEAM teachers" professional growth	• Enhance pedagogical skills *(29)* • Opportunity for collaboration *(22)* • Reinforce teaching with technology *(14)* • Understanding TPACK in Philippine STEAM education *(14)* • Make relevant lesson exemplar *(12)*
Least expected in the training and orientation (CBP)	• No sample lesson exemplar *(6)* • Limited time for workshop *(4)*

The overall positive impression on the TPDP may have been due to a solid and strong training design (Hill, 2012), which is quite new to these teachers who usually indulge in research conferences for their professional growth, and that most TPDPs for teachers in the country focus on training teachers for basic education levels (Zepeda, 2016). Consequently, sampled teachers‟ insights elaborate the following attributes of effective TPDPs: content focused *(sharing of baseline data for TPDP and visualizing STEAM teachers' intent on improving the Philippine STEAM education)*, incorporates active learning and elements of adult learning theory *(relevant workshops and development of LEs)*, employs co-development and co-learning, and job-embedded contexts (*enhance pedagogical skills and opportunities for collaboration*), uses peer coaching and expert support (*reinforce teaching with technology and consultation*), and offers opportunities for feedback and reflection (Darling-Hammond et al., 2017).

Part of the insights of STEAM teachers are points for improvement of the succeeding TPDPs, which mainly focused on non-provision for samples of LEs (which the team intentionally did to bring out the design skills of teachers), thereby exuding their being curriculum planners (Jadhav & Patankar, 2013), and limited time for the workshop. They feel that workshops are part of the program that can provide them with immense learning (Hill, 2012), and even improve their social and emotional intelligences (Talvio et al., 2016). Hence, TPDPs may focus on such activities and go less on the lecture portions, the thing called "*flipping it*" as Burns (2018) presents flip TPDPs.

The quantitative evaluation seems to elucidate attainment of the set objectives (Carliner, 2015) with an average rating of the participants as 3.56 (*SD*= .65) out of 4 interpreted as excellent. Affirmation of the results through the qualitative data shows that participants were able to "*gain updates about the current trends and issues on STEAM Education*," obtain familiarity of the "*different STEAM models presented*," develop a "*better understanding of the application of the STEAM education models*" through the lesson exemplar presentation, and that they were able to "*create linkages with other STEAM educators*" in the country. From here, the impression is that in general, the sampled STEAM teachers felt that the TPDP was able to achieve the objectives. In fact, majority (85 out of 106, 80%) of them perceive that the TPDP provided them knowledge and understanding of different teaching and learning domains for them to improve how they enact STEAM lessons. They (83 out of 106, 78%) claim that they learned new techniques on how to conceptualize STEAM lessons using integrated STEAM disciplines, which acquainted them to techniques on how to enhance their teaching proficiency as STEAM teachers. They (86 out of 106, 81%) claim that they learned the following: 1) contextualizing the delivery of STEAM lessons, 2) how STEAM lessons are planned anchored on the how they model and visualize the Philippine STEAM education, and 3) how to develop lesson exemplars.

Seemingly, their observations and evaluation on their crafted LEs in terms of meaningful engagement of learners pre-empted their positive evaluation of the TPDP. They assessed the program as good to excellent in all aspects. They also conveyed that they learn "*new advances in technologies applied in learning situations*" and they perceived that "*the information, model, trends, and many other things* [discussed in the TPDP] *were essential*" to them as STEAM teachers. The TPDP also provided them with an opportunity to "*assess*

[themselves] *as a teacher in terms of pedagogy, content, and assessment*" and "*gain insights on how to teach better*," thus allowing them to be more reflective practitioners.

The overall implementation of the TPDP also received positive feedback from the participants (through their presented impressions and reflection before concluding the TPDP). In fact, all aspects of the program (educational content, relevance to practice, topics, questions and discussions, workshops, presentations, logistics and communications, and venue and refreshments) received an excellent rating from the participants. They emphasize that all members of PAR-Group 1 who shared information were "*very informative/knowledgeable*" and "*exceptional*" in their respective presentations. Most importantly, they value their "*participation and role in the training*" and they thought that the TPDP is "*more meaningful since they* [were] *part of the entire process*."

Conclusion and Recommendations

The study designed, implemented, and documented the TPDP for PHE STEAM teachers. The study focused on LEs ascribed to the model of the current condition of STEAM education, and how the sampled STEAM teachers envision it to develop STEAM-skilled citizens. The TPDP emphasized holistic attribute of a transformative training, and personal and professional development that features hierarchical (from core team to participants) and transformative roles (transition from participants to researcher-participants to co-researchers) in the study. It also highlights the principle of community of learning, peer teaching, peer review, modelling, monitoring, and mentoring. In fact, the TPDP covers the entire spectrum of the sequence of model orientation, model concretization (through development of LEs) and model evaluation as well. Specifically, the development of LEs in the part of the study where participants (called discipline-based clusters) transition to being participant-researcher in a community learning system highlight the following PSE features: teacher pedagogical character, provision for modality, teacher technological knowledge, equity, diversity form of institutional support, and assessment. Elaborations and articulations of these features of the PSEM imply highly skilled Filipino STEAM teachers of higher and advanced learning. They showed capability or skill of being able to detail and expound the features of the suggested model, which means that they exhibit skills in correctly and effectively interpreting the model through articulation in LEs. This scenario implies that they may be able to model, monitor and mentor others as well. Additionally, distinct parts (reflections and enrichments) of LEs showcased how STEAM teachers may be upskilled to being reflective practitioners exemplifying the culture of reflection-in-action and reflection-on-action through their engagement in the implementation of the LEs as action research in their respective classes.

Seemingly, the LE development as part of the TPDP strengthened teachers" design thinking skills and developed their sense of being curriculum designers/developers. The LE development exercise gave them a sense of mastery orientation, and an authoritative figure in designing engaging lessons for the STEAM disciplines (as their tool for their action to extract high student engagement through action research). Such may eventually lead to significant student learning and improvement. Furthermore, this development and implementation study as the key parts of the TPDP may have advanced the habit of the mind, and culture of feedback and reflection mechanism among the participants. It reinforced the development of reflective practice and evolved STEAM

teachers into reflective practitioners. Their capability to reflect on their lessons and on the TPDP itself is indicative of their positive reception to feedback, criticism, and learning, and their willingness to model, be monitored and be mentored as well.

The defined validation (of LEs) strategy presents a novel way of deducing content and face validity that highlights reflective practice (for the peer review scheme) and multi-perspective mindset validation for panel critiquing. A feedback system as such may have generated valuable insights on the part of the sampled STEAM teachers, in which they have incorporated in their LE designs and revision. As a consequence, they encountered synergy in student engagement and student-teacher interaction/relation. These effects may have motivated them to teach as they share a sense of ownership, novelty and service to the teaching profession and STEAM education.

In sum, the TPDP emphasized the holistic attributes of a transformative training, and personal and professional development that may be ascribed to three key points: product, process and power. Meaningful products were deduced in each of the phases as per phase requirement (baseline data with visual of STEAM education"s current and envisioned condition, TPDP, use of PAR in TPDP, TPDP design, implementation, validation, and evaluation, co-developed Lesson Exemplars). But, commonalities in each phase are within the processes and power aspects. Processes and power sip into each of the phases defining the products or outcomes of each phase. Specifically, in each of the phases, the PAR-cycle evidently manifests new concerns evolving in every phase. Reflections, reflexive actions, assessment, evaluation and all the processes in this phase contributed to the attributes of PAR as the methodical framework of the TPDP: co-learning, co-development, balance of power, shared and multiple realities, communicative space, and equitable partnership.

Power in each of the phases embodies empowerment rather than a hierarchical nature as in the case of traditional research. Specifically, this sense of empowerment is experienced by all participants which means that balance of power is also evident in the entire TPDP. By and large, the study was able to capitalize "*balance of power*" in securing the learning experiences of the participants which may enable emancipation on their part through strengthening of their self-efficacy. Consequently, such improved conditions of STEAM teachers and education may highlight transformative and social changes and hope to provide significant development in STEAM education. The findings of this study may be unique to this set of samples noting the differently defined "A" in STEAM being an agricultural country. Nevertheless, transferability of the knowledge generated in using PAR as a methodical framework for TPDP, and capitalizing on the novel assessment methods presented in this study, may also work and may be explored in other countries and contexts.

Though the presentations were within the national scale, only a few LEs were developed. The aim is to populate the HEIs in the country with the developed and validated LEs directed by the model for better STEAM education. Replicate studies may adopt the instituted processes to increase productivity of STEAM teachers of LEs. In this sense, we may be able to produce STEAM-literate learners and a strong Filipino workforce for the next industrial revolution era.

Acknowledgements

This work was supported by the Grant-in-Aid Program of the Philippine Commission on Higher Education (Commission en Banc Resolution No. CEB Resolution No. 245-2011) and Philippine Normal University (Board of Regent Resolution No. U-2650, s.2017). Instruments are available at http://pnu-onlinecommons.org/omp/index.php/chedpnutpack/catalog/book/1096

References

Ark, T.V., & Meyers, A. (2018, December 18). Why experiential education? Retrieved from hArkttps://www.gettingsmart.com/2018/12/why-experiential-education/.

Burns, M. (2018). *Using checklists to establish smoother tablet routines*. Retrieved from https://www.teachthought.com/pedagogy/using-checklists-to-establish-smoother-tablet-routines/. Accessed on 5 May 2020.

Carliner, S. (2015). *Training Design Basics* (2nd ed.). ATD Press.

Chandler, D., & Torbert, W. R. (2003). Transforming inquiry and action: Interweaving 27 flavors of action research. *Action Research*, *1*(2), 133-152.

Commission on Higher Education. (2015). *Policy reforms for the grants-in-aid funds of the Commission on Higher Education (CHED) for research and development, and extension*. Retrieved from https://ched.gov.ph/wp-content/uploads/2017/10/CMO-no.-03-s.-2015.pdf. Accessed on 5 May 2020.

Commission on Higher Education. (2019). *2019 higher education facts and figures*. Retrieved from https://ched.gov.ph/2019-higher-education-facts-and-figures/. Accessed on 6 May 2020.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Retrieved from https://learningpolicyinstitute.org/sites/default/files/product-files/Effective_Teacher_Professional_Development_REPORT.pdf. Accessed on 6 April 2020.

DePaul (2019) Teaching Commons: Course Objectives & Learning Outcomes. Retrieved from https://resources.depaul.edu/teaching-commons/teaching-guides/course-design/Pages/course-objectives-learning-outcomes.aspx. Accessed on 6 April 2020

Fiddis, R. (2017). *The importance of STEM education to the economy*. Retrieved from https://www.theceomagazine.com/business/innovation-technology/importance-stem-education-economy/. Accessed on 5 May 2020.

Gibbs, P., Cartney, P., Wilkinson, K., Parkinson, J., Cunningham, S., James-Reynolds, C., Zoubir, T., Brown, V., Barter, P., Sumner, P., MacDonald, A., Dayananda, A., & Pitt, A. (2017). Literature review on the use of action research in higher education, *Educational Action Research*, *25*(1), 3-22. https://doi.org/10.1080/09650792.2015.1124046

Gillis, A., & Jackson, W. (2002). *Research methods for nurses: Methods and interpretation*. F A Davis Co.

Hand, C., Rudman, D. L., McGrath, C., Donnelly, C., & Sands. M. (2019). Initiating participatory action research with older adults: Lessons learned through reflexivity. *Canadian Journal on Aging*, *38*(4), 512-520. https://doi.org/10.1017/S0714980819000072.

Hill, L. (2012). *The value of workshops and continuing education for teachers.* Retrieved from https://evolllution.com/opinions/the-value-of-workshops-and-continuing-education-for-teachers/. Accessed on 7 April 2020.

Infosys. (2016). *Amplifying human potential: Education and skills for the fourth industrial revolution*. Retrieved from http://boletines.prisadigital.com/%7B6139fde3-3fa4-42aa-83db-ca38e78b51e6%7D_Infosys-Amplifying-Human-Potential.pdf. Accessed on 5 May 2020.

Jadhav, M., & Patankar, P. (2013). *Role of teachers' in curriculum development for teacher education*. Retrieved from https://www.researchgate.net/publication/258023165_ROLE_OF_TEACHERS'_IN_CURRICULUM_DEVELOPMENT_FOR_TEACHER_EDUCATION. Accessed on 7 April 2020.

Johnson, B. (2012). *How do we know when students are engaged?* Retrieved from https://www.edutopia.org/blog/student-engagement-definition-ben-johnson. Accessed on 7 April 2020.

Kelly, P. J. (2005). Practical suggestions for community interventions using participatory action research. *Public Health Nursing*, *22*(1), 65-73. https://doi.org/10.1111/j.0737-1209.2005.22110.x

Kemmis, S. (2006). Participatory action research and the public sphere. *Educational Action Research*, *14*(4), 459-476. https://doi.org/10.1080/09650790600975593

Kemmis, S., & McTaggart, R. (2000). Participatory action research. In N. K. Denzin & Y. S. Lincoln (Eds.), Handbook of qualitative research (2nd ed., pp. 567-607). Thousand Oaks, CA: Sage.

Kennedy, A. (2014). Models of continuing professional development: A framework for analysis. *Professional Development in Education*, *40*(3), 336-351. https://doi.org/10.1080/19415257.2014.929293

Monde, J. (2019). *Agriculture Schools In Philippines: Universities Offering This Course*. Retrieved from https://philnews.ph/2019/03/29/agriculture-schools-philippines-mindanao-course/. Accessed on 6 May 2020.

Morales, M. P. E. (2016). Participatory action research (PAR) cum action research (AR) in teacher professional development: A literature review. *International Journal of Research in Education and Science, 2*(1), 156-165.

Morales, M. P. E., Anito, J. V., Avilla, R. A., Abulon, E. L. R., & Palisoc, C. P. (2019). Proficiency indicators for Philippine STEAM (Science, Technology, Engineering, Agri/fisheries, Mathematics) educators. *Philippine Journal of Science*, *148*(2), 263-275.

Morales, M. P. E., Avilla, R. A., Palisoc, C. P., Elipane, L. E., Sarmiento, C. P., Ayuste, T. O. D., Palomar, B. C., Anito, J. C., Butron, B. R., Bernarte, R. P., Viray, K. R., Sagun, R. D., Padama, A. A. B., Roxas-Villanueva, R. M., Prudente, M. S., Nepomuceno, C. T., Bornales, J. B., Mercado, F. M., Pagkatipunan, P. M. N., Alcantara, E. C., & Casilla, N. A. (2019). *TPACK in Philippine STEAM education (Technical Report)*.

Morales, MPE., Palisoc, C., Avilla, R., Sarmiento, C., Palomar, B., & Ayuste, O.T. (2020). Self-professed proficiency of Philippine higher education (PHE) teachers of STEAM disciplines. The Philippine Journal of Science, 149(2), 415-426.

Ohize, E. J. (2017, April 24-28). *Repositioning Science, Technology, Engineering and Mathematics education for economic recovery in Nigeria*. 11th National Conference "Reposition Science, Technology, Engineering & Mathematics (STEM) Education for Economic Recovery in Nigeria", Federal College of Education, Kontagora, Niger State.

Pino-James, N. (2014, December 8). *Golden rules for engaging students in learning activities.* Retrieved from https://www.edutopia.org/blog/golden-rules-for-engaging-students-nicolas-pino-james. Accessed on 7 April 2020.

Reason, P., & Bradbury-Huang, H. (2001). *Handbook of action research: Participative inquiry and practice*. SAGE Publications Ltd.

Sarikas, C. (2020, January 4). *Vygotsky Scaffolding: What it is and how to use it*. Retrieved from https://blog.prepscholar.com/vygotsky-scaffolding-zone-of-proximal-development. Accessed on 7 April 2020.

Sato Y. (2012). Human Security and the Peace-Building Paradigm: A Japanese Experience and Perspective. In: Toyoda T., Nishikawa J., Sato H.K. (Eds.), *Economic and Policy Lessons from Japan to Developing Countries* (pp. 255-268). IDE-JETRO Series. Palgrave Macmillan, London. https://doi.org/10.1057/9780230355019_15

Schon, D. A. (1984). *The reflective practitioner: How professionals think in action*. Basic Books.

Seale, C. (2020). *A perfect time to end our stem obsession: 3 ideas for teaching critical thinking at home during (and after) the coronavirus pandemic*. Retrieved from https://www.forbes.com/sites/colinseale/2020/03/15/a-perfect-time-to-end-our-stem-obsession-5-ideas-for-teaching-critical-thinking-at-home-during-and-after-the-coronavirus-pandemic/#760c2b5f252e. Accessed on 5 May 2020.

Somekh, B., & Zeichner, K. (2009). Action research for educational reform: remodelling action research theories and practices in local contexts. *Educational Action Research*, *17*(1), 5-21. https://doi.org/10.1080/09650790802667402

Talvio, M. , Berg, M. , Litmanen, T., & Lonka, K. (2016). The benefits of teachers‟ workshops on their social and emotional intelligence in four countries. *Creative Education*, *7*(18), 2803-2819. https://doi.org/10.4236/ce.2016.718260

The Report: Philippines (2017). Retrieved from https://oxfordbusinessgroup.com/philippines-2017/country-profile

Tikly, L., Joubert, M., Barrett, A. M., Bainton, D., Cameron, L., & Doyle, H. (2018). *Supporting Secondary School STEM Education for Sustainable Education in Africa*. Retrieved from https://www.bristol.ac.uk/media-library/sites/education/documents/Supporting%20Secondary%20School%20STEM%20Education%20for%20Sustainabale%20Development%20in%20Africa.pdf. Accessed on 5 May 2020.

Tummons, J. (2010). The assessment of lesson plans in teacher education: a case study in assessment validity and reliability. *Assessment & Evaluation in Higher Education*, *35*(7), 847-857. https://doi.org/10.1080/02602930903125256

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher–student interaction: A decade of research. *Educational Psychology Review*, *22*, 271-296. https://doi.org/10.1007/s10648-010-9127-6

Walker, M., & Loots, S. (2018). Transformative change in higher education through participatory action research: a capabilities analysis. *Educational Action Research*, *26*(1), 166-181. https://doi.org/10.1080/09650792.2017.1286605

Zenobia, I. (2018). *Benefits of STEM education*. Retrieved from https://assets.publishing.service.gov.uk/media/5c6c0ec740f0b647abb525a7/418_Benefits_of_STEM_Education.pdf. Accessed on 5 May 2020.

Zepeda, S. J. (2016). Principals‟ perspectives: professional learning and marginal teachers on formal plans of improvement, *Research in Educational Administration & Leadership*, *1*(1), 25-59.

Author Information

Marie Paz E. Morales
https://orcid.org/0000-0003-3240-9436
Philippine Normal University
College of Graduate Studies & Teacher Education Research, Taft Ave., Ermita, Manila, 1000 Metro Manila
Philippines
Contact e-mail: *morales.mpe@pnu.edu.ph*

Felixberto M. Mercado
https://orcid.org/0000-0003-3845-7471
Manuel S. Enverga University Foundation
Enverga Blvd, Ibabang Dupay, Lucena, 4301
Quezon
Philippines

Caesar P. Palisoc
https://orcid.org/0000-0001-8724-9519
Philippine Normal University
College of Graduate Studies & Teacher Education Research, Taft Ave., Ermita, Manila, 1000 Metro Manila
Philippines

Brando C. Palomar
https://orcid.org/0000-0001-7792-5069
Philippine Normal University
Faculty of Science, Technology & Mathematics, Taft Ave., Ermita, Manila, 1000 Metro Manila
Philippines

Ruel A. Avilla
https://orcid.org/0000-0003-3803-5623
Philippine Normal University
Faculty of Science, Technology & Mathematics, Taft Ave., Ermita, Manila, 1000 Metro Manila
Philippines

Celina P. Sarmiento
https://orcid.org/0000-0003-0220-216X
Philippine Normal University,
College of Flexible Learning & e-PNU, Taft Ave., Ermita, Manila, 1000 Metro Manila,
Philippines

Benilda R. Butron
https://orcid.org/0000-0002-8312-3473
Philippine Normal University,
Faculty of Science, Technology & Mathematics, Taft Ave., Ermita, Manila, 1000 Metro Manila
Philippines

Thaddeus Owen D. Ayuste
https://orcid.org/0000-0002-1522-2373
Philippine Normal University
Faculty of Science, Technology & Mathematics, Taft Ave., Ermita, Manila, 1000 Metro Manila
Philippines