Capacity Building in Teaching Mathematics through Problem Solving

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Abstract. Drawing from the national evaluation of the DOST-SEI’s project STAR, this paper presents the case of the Northern Mindanao. Teaching Mathematics through Problem Solving (TMPS), interdisciplinary contextualization, and Lesson Study are the main training content of the project STAR. A good mixture of theory presentation, demonstration, practice, feedbacking and coaching compose the typical training design of the project. This evaluation study revealed that the training from 2014-2017 have applied the training content in different settings, mostly in the classroom and among small group of teachers. The participants’ teaching practice are impacted by the training evidenced by the change of their beliefs, attitudes and roles in the classroom. Teacher participants also claimed to have gained professional skills as they continue on their implementation but have also encountered various challenges such as the lack of monitoring and feedback. Form the insights on student interviews and class observations, there are evidences that students indeed benefitted from the teachers’ implementation of the training content. Recommendations based from the results are also discussed.

1. Introduction

The basic education landscape in the Philippines changed upon the implementation of the Enhanced Basic Education Act of 2013, the law that implemented the K-12 educational system. Accompanying the change is the challenge on the change of perspective of effective teaching of mathematics. The Department of Science and Technology - Science Education Institute (DOST-SEI) with the Philippine Council of Mathematics Teacher Educators (MATHTED) Inc. published the Mathematics Framework for Philippine basic education focusing on the achievement of mathematical empowerment where the development of critical and analytical thinking at its core [12]. The framework of the K-12 mathematics curriculum also focuses on two goals: the development of critical thinking and problem-solving skills among the Filipino learners. Hence, transitioning from the conventional teaching of mathematics towards a more student-centered approach in delivering mathematics, efforts have been made to capacitate sizeable force of teachers and administrators to institute change in the field of teaching mathematics.

With the mandate of capacitating the country’s human resources in science and technology, DOST-SEI conducts many projects towards this goal which teacher training is among them. Since
2014, DOST-SEI organized a scheme of capacity building efforts aimed at increasing instructional capacity and content knowledge of teachers with the end goal of enhancing the teaching and learning of science and mathematics known as Project STAR. The project has the following goals: a) to develop a critical mass of science and mathematics teachers all over the country (in-service) and b) to promote new strategies and models in the teaching and learning of science and mathematics (in-service/pre-service). Teaching mathematics through problem solving is one of the approaches promoted by the Project STAR. While many studies support the effects of using teaching mathematics through problem solving in teaching mathematics [e.g., 10, 2, 5], data from the Philippine setting on the effectiveness of the approach is not yet established.

A typical training design for training mathematics teachers on Teaching Mathematics through Problem solving is composed of the following components: 1) Expounding the K-12 Mathematics framework; 2) Discussion on Interdisciplinary Contextualization; 3) Lesson Study (LS): a Framework for School-based Professional Development; 4) Teaching Mathematics through Problem solving; 5) Sample Lesson Implementation using TMPS, with LS Post Lesson Discussion; 6) Collaborative Lesson Planning; 7) Implementing the Lesson Study Cycle and 8) Implementation on Real-life classroom. The components of the training roughly contain most of the components listed by [18] which are factors that can determine the impact of the training. These components are as follows: presentation of theory; modelling or demonstration; practice under simulated conditions; feedback and coaching for application.

Mathematics K-12 framework serves as a guidepost towards the attainment of the goals of the Mathematics education in the Philippines- Filipinos who are mathematically empowered [12] with a focus on the development of critical thinking and problem-solving skills. The following are overviews of the different parts of the training and how it is conducted:

**Interdisciplinary Contextualization.** This part of the training brings together two concepts known to the field of teaching and learning, that is, interdisciplinary instruction and contextualization. Interdisciplinary means connecting one or more disciplines being integrated as one. Where by contextualization, conceptualization and problem-solving are suggested to be strategies to apply interdisciplinary teaching [11]. In this segment of the training, participants are taught to make lessons and problems more relevant (humanizing knowledge) to the students as it cuts across curriculum areas (across disciplines). Context such as local culture, environment, lifestyle, and student experiences are among those emphasized as themes where contextualization occurs. [1] noted that contextualization is “...relating subject matter content to meaningful situations that are relevant to students’ lives…” p.1. This indeed is the goal of the segment on Interdisciplinary Contextualization.

**Teaching Mathematics through Problem Solving.** Problem Solving Approach has been known as Japanese teaching approach [6]. As a result of cyclical refinement of classroom teaching through lesson study, problem solving approach emerged in the Japanese mathematics instruction. The structure of the Japanese problem solving approach described by [15] as having the following parts: a) Review of the previous lesson, b) Presenting the problem, c) Students solve the problem individually or in groups, d) Students share their solutions and e) Summary of the lesson. In the STAR training, emphasis is given on distinguishing what [9] mentioned as the three approaches to problem solving: teaching for, about and via/through problem solving. [5] along other researchers described “Teaching through Problem Solving” (TIPS) as a “pedagogy that engages students in problem solving as a tool to facilitate students’ learning of important mathematics subject matter and mathematical practices” (p. 455) laying some key “moves” to describe the approach: (1) Posing a worthwhile problem with its mathematical complexity, (2) letting the students explore the problem, build conjectures … and letting them share their work, (3) from their shared work, focus on the big mathematical idea or concept, (4) build the concept or idea from the contribution of the individual or groups, pointing out mistakes and misconceptions in the process and (5) closure: provide time for students to reflect on what they learned. Several other researchers paint a similar picture [e.g., 9, 10, 4, 13]. A similar framework is laid out in the Philippines which is as follows: (1) presentation of the problem, (2) students explore and solve the problem collaboratively, (3) processing of the lesson and (4) summarization.
Lesson Study. [17] defines Lesson study (LS) as “... a teacher led, school based continuing professional development model that originated in Japan” p.1 where it is a practice since 1800’s [6]. Essentially, the LS framework used in the STAR trainings has the following components: 1) planning a research lesson, 2) Implementation of the Research Lesson and 3) Post-Lesson Reflection and Discussion all in the context of collaboration. This is what [16] coined as the Lesson Study Cycle. The input on LS helps the teacher change their focus from the teacher to the students and their learning.

Workshops. The workshop is composed of many activities including the collaborative lesson planning, crafting of contextualized open-ended problems, simulating the Lesson Study cycle within group and then the actual lesson and lesson study implementation in the real-life classroom. The workshop on creating open-ended problems introduces to the teachers the importance of divergent problems and introduces strategies in crafting one. With an on-site lesson implementation using the teaching mathematics through problem solving as approach, the teachers will then use their crafted open-ended problems to plan out a lesson to be implemented. After a round of critiquing both by the trainers and their co-participants, the teachers will simulate the LS cycle within groups of teachers to refine the lessons crafted. After the process of refining the lesson using the LS cycle, the teachers will implement their lessons in a real classroom and then refine the lesson according to how the students responded to the lesson. This way, the teacher participants will have to be able to see for themselves the effects of using the approach, both the benefits and limitations.

From 2014-2017, DOST-SEI thru Project STAR have conducted five trainings for Mathematics in the Northern Mindanao Region or the Region X in the Philippines. After three years of continuous training and coordination to the different regions, a national evaluation of the STAR trainings was launched in 2018 to gauge the effectiveness of the STAR training in the participating regions. This paper hence, presents the case of Region X. In particular, this paper intends to determine the extent and quality of adaptation of the STAR training content and skills into the participants’ teaching practice and identify the impact of the STAR training on teaching practice as well as professional and personal growth of the participants.

2. Methods
This evaluation utilized the Kirkpatrick’s Model of Training Evaluation. As we are interested to gauge the extent and quality of the teacher participants’ adaptation of the training content; and the training’s impact on their teaching practice, Kirkpatrick’s levels of evaluation corresponds to the objectives of the evaluation namely: Reaction, Learning, Behavioral Change and Organizational performance growth of the teacher participants.

Level 1 of the evaluation concerns with the Reaction of the participants. This would cater to the participants’ perceptions on the training; their likes, how do they feel among others. Level 2 evaluation concerns primarily of Level 1 of the evaluation concerns with the Reaction of the participants. This would cater to the participants’ perceptions on the training; their likes, how do they feel among others. Level 2 evaluation concerns primarily of their Learning. This would point towards the participants’ newly learned skills, knowledge and attitudes. Usually, this pertains to the comparison between what they (skills, knowledge, attitudes) have before the training and after the training. The third level of the evaluation model is Transfer. This concerns the participants’ application and adaptation of the
training content to their teaching and finally, level 4, Results. Results explores the results of the training. Evaluation at this point paints the picture of having the attainment of the goal of the training [8].

2.1 Subjects of the study
The respondents for the evaluation study are the Project STAR participants since 2014-2017. These participants took the online survey (n=43) which would make them qualify for the FGD (n=6) and the classroom observations should they be selected (n=3). In the selection of the FGD participants, the participants are classified into three, based on the mean ($\bar{x}$) and standard deviation(SD), that is, 2 participants below the $\bar{x} - SD$, above $\bar{x} + SD$ and within $\bar{x} \pm SD$. Finally, some of the participants’ students will be interviewed with the permission of their class advisers. Furthermore, the direct superiors of the observed participant will also be interviewed.

2.2 Data Collection
To achieve the objectives of the study, four (4) phases of data gathering is designed to gather appropriate data for analysis. The phases of data gathering, and their respective instruments are as follows: 1) Online Survey (Project STAR Survey Questionnaire); 2) Focused Group Discussion (FGD Questions); 3) Interview (Supervisor and Student Interview Guides) and 4) Classroom Observation (Classroom Observation Notes and Rubric).

After getting permission from the Department of Education Regional Office X, the online survey was floated to the participants for a whole month and the responses of the survey form the basis for the selection of the FGD participants. Upon selecting the participants, and confirming their attendance to the FGD, the FGD was conducted. Their responses were transcribed and analyzed to produce themes relating to the different dimensions of their experience of implementing the training content in their respective teaching careers. From the FGD, the evaluating team picked three (3) FGD participants to be visited in their respective schools for observation and interview. In the class observations, evaluators observe the implementation of the training content the TMPS approach, the contextualization of lessons and the Lesson Study. To confirm the findings of the observations, select students were asked to be interviewed to confirm the effects of the teaching approach used. The supervisors are asked to verify whether there have been improvements on the teacher’s performance and initiatives related to the implementation of the training content. Written consents were taken from the participants prior to their participation in the data gathering procedures mentioned. Data from the survey are transformed into quantitative data for interpretation. Descriptive analysis of the quantitative data is employed. The qualitative data is analyzed to produce themes in support of the quantitative data gathered.

2.3 Research Instruments
There are four instruments used in the evaluation study, namely: 1) Project Star Survey Questionnaire (PSSQ); 2) Focused Group Discussion Guide; 3) Student and Supervisor Interview Guides and 4) Classroom observation tool. The PSSQ surveys the participant’s consent, relevant personal information, training attended, teaching practices and professional attributes. The FGD guide contains 14 confirmatory questions to the PSSQ. It contains some closed ended and open-ended questions depending on the data required. Generally, the FGD focuses on the following: difference of STAR trainings from other trainings attended, improvement of teaching practice, evaluation of pedagogy; system support; student benefits; sharing of practice; personal and professional development and impact of STAR training. Student and Supervisor Interview Guides. These guides contain questions that triangulates certain responses from the FGD and the classroom observations. The Student Interview guide contains nine (9) questions that gather information about their teacher’s pedagogy; teacher activities; perceptions and extent of the pedagogy’s influence on their plans. The Supervisor interview guide on the other hand contains only five (5) questions which gather information on the supervisor’s perspective on the change of practice in the STAR trainee in terms of practice and lesson planning; help extended for the STAR trainee and the STAR trainee’s effort of sharing the practice.
Classroom Observation Tools. There is a total of three available tools for observation, two of which are used as the primary tools and one as a supplemental one. The primary tools contain the following areas of consideration: (1) Instruction Factors; (2) Discourse Factors; (3) Assessment Factors and (4) Lesson Factors associated with Inquiry-based instruction. The supplementary tool used is a checklist also considering the following areas: (1) Lesson Planning; (2) Content and Pedagogy Knowledge; (3) Communication Skills and (4) Classroom management.

3. Results and Discussions

Results discussed are presented such that it directly answers the research questions of this paper. It integrates the findings from the survey, the FGD and the interview results to triangulate the data presented. The presentation of the results is of three parts, namely the extent of application and adaptation, teacher practices, professional skills and impact to students.

3.1. Extent of Training Application and Adaptation to teaching practices

Among the mathematics participants from 2014-2017 in the region, around 48% responded to the online survey (n=43). The participants are mostly at the Teacher I position (25.6%) and the Master Teacher I (25.6%), with 14% being Principals and the rest are distributed sparsely among teacher and administrative ranks with a few Education Program Supervisors. Relatively, such distribution of participants affects the scope of how they can adapt and implement the training contents from the Project STAR. Figure 3 summarizes in what context were the participants able to apply the training content.

![Figure 2. Context of application of training content](image)

The teacher participants mostly apply the training content in the classroom and with a small group of teachers. Their application in the classroom mostly includes contextualization of their lessons, rudiments of interdisciplinary instruction and the teaching mathematics through problem solving approach. Some other participants also claimed to have shared their learning to a small group of teachers in their school. This is evident in their involvement to their learning action cells [3] utilizing the Lesson Study framework. Survey results showed that nearly 63% of the respondents involve themselves in a lesson study group. Some other teachers are also tapped in several Division Trainings and others are also involved in the regional trainings. One participant was able to attend an international conference presenting a paper relating to his teaching practice applying the training content. The practices of the teacher participants are further detailed in the next section.

3.2. Teacher Practices of Respondents

The teaching practices survey tackled specific teaching practices among the survey participants. It has 30 statements (See Appendix 1) relating to interdisciplinary contextualization and localization, student-centered instruction, problem-solving, critical thinking and other personal practices.
Mostly, the statements of the survey are stated in positive way and a few others in negative way; which are also computed in reverse. Highlights of the survey would include teaching practices that are particularly high among the teacher participants, and those who have particularly low agreement among the participants. Among those who garnered a strong agreement are statements pertaining to localization and contextualization, focusing on the relevance of the lesson to students’ context and experience: “I use real-life context to make learning more meaningful. (S4)” (M=3.767, SD=0.427); “I consider prior knowledge and experiences of my students in teaching. (S5)” (M=3.674, SD=0.474); “I provide concrete examples to make connections with the students’ personal experiences. (S6)” (M=3.605, SD=0.495); “I use real-life situations in assessing learning objectives. (S12) (M= 3.744, SD=0.44)”; “I ensure that math concepts learned are related to real-life experiences. (S30)” (M=3.767, SD=0.427). While all other positive statements also have varying strong agreement, the negative statements revealed that teachers still do retain some conventional teaching practices: “I do not relate the topic to other disciplines (S2)” (M=3.163, SD=0.688); “I discuss the subject matter at hand without relating to other fields. (S7)” (M=2.953, SD=0.844); “I follow totally what is in the reference book when discussing a topic. (S10)” (M=2.628, SD=0.757); “I assume that a lesson plan is effective because I have been using it for a long time. (S16)” (M=2.442, SD=0.881); “Most of the time, I do the talking in class. (S24)” (M=3.093, SD=0.718). The survey results indicate that most of the teachers apply contextualization in their classes, while others try applying some other content, may have met challenges limiting their practice. Furthermore, some still retained conventional practices, contrary to the expectations, based on the training content.

The focused group discussion revealed much of these challenges and benefits the teachers experienced through the training. One particular example why there has been a high classroom applicability of the training content, one participant explained “... teaching through problem solving is quite new to me ... I said that this can’t be done by all of my third graders, this is fit for fourth graders. But when I tried it, wow! I was amazed it’s because they were able [to] ... even third grade section B, see? M2”. In this regard another participant agreed as she explains: “Because of that approach, you can discover that this learner has some idea, ... if not for the approach, you can never elicit what he/she is thinking, although it is quite laborious ... for the teacher, it is quite fulfilling. M3”. The training helped the teachers on supporting peers; promoting equity-mindset; developing the skill contextualization and developing problems and processing and provided a clear curricular direction. These help they got from the training translated into varied benefits they claimed to have been a direct result of their training in the project.

![Figure 3](image_url)

**Figure 3.** Benefits gained by teacher-participants from the training

The teachers expressed that there are many benefits they have received from the training that they are able to apply in their teaching. On the effective use of concrete materials, the teacher participants shared that through the training, they are encouraged to use manipulatives to explore important mathematics, stressing on the benefit of students being able to express their ideas. One teacher mentioned: “... they [students] are using it through ... expressing themselves usually and then they can learn better ... with one manipulative, those thoughts that they can’t express mentally, they properly do when they have something to touch ... yes, concrete objects... M1”. One teacher just used a ruler and a ribbon to explore the relationship of the diameter and the circumference to approximate
the value of the pi. The teacher just asked the students to explore any circular objects in the classroom such as vases’ bottom, paper plates, circular wall clock. The teacher mentioned: “... I was very happy that they are able to [say] ... ‘the relationship between the diameter and the circumference is almost 3.14 times.’ Because when they measured ... I asked them ‘Let us see the relationship of the circumference and the diameter even if the object is smaller ... M3’”. The transition from being teacher-centered to a more student-centered mathematics classroom is evident in the teachers’ experiences even if it counts only as a part of their experience.

Teachers have also become more confident in teaching mathematics, as one teacher mentioned, “... the personal thing that I gained from the training was that ... the confidence when there are some surprise visitations. M4”. In the Philippines, teachers often panic from surprise observations from superiors. Somehow, the training equipped some of the teachers the confidence to teach with or without supervisors’ presence. This is particularly rooted in the development of the development of their ‘processing’ skills and their perceived advantage in the Department of Educations’ Results-based Performance Management System (RPMS) evaluation. One teacher explained: “Because I was able to the other teachers what indicator number 1 [on the RPMS] ... [states] ‘... content across other learning areas’ which was given in the [training of project] STAR ... in contextualization and interdisciplinary! ... the number 3 indicator ... which is to develop ‘critical thinking’ was also given by the STAR. M3”. Apparently, the training content of the project helped them realize the urgent need to develop the 21st century skills, problem-solving and critical thinking which they also expressed as a clear guidance towards curricular goals in teaching mathematics. Furthermore, their confidence, can be attributed to the development of their ‘processing’ skills.

Varied expressions from teachers revealed different aspects of this processing skill: on assessing students, “... sometimes, the discrepancy is in their comprehension, not in the calculation... If I do not use teaching through problem solving, we cannot evaluate where the discrepancy is and where their strength is. M3”; on questioning: “... the use of giving questions? Right? The art of questioning? M4”; and on processing student idea: “... the way I process the content so that each learner would be given the chance to reason out, would be given the chance to relate the content into the real life situation and will make sensible discussion. M3”.

Aside from having developed various skills, the participants also had improvements in their attitudes towards students and teaching, towards their peers and their own professional development. By implementing what they have learned from the training, the teachers, believed that they became more patient when dealing with their students, improved their view of teaching and increasing their passion towards student learning. One teacher mentioned: “... I become more kind, ... [with] more patience. Before, I do not usually ... but now, I can already say ‘alright, let’s try to find out if there is something wrong’... So, that is the best benefit I had ... to be open and kind. M3”. The same teacher also expressed that it was through the training that she changed her perspective: “... I really appreciated about the training is the passion to draw the potential, to draw the genius, the genius in the class that we do not expect was in that child ... the training have changed my perspective. M3”. Another teacher also shared how his perspective have changed from that of a teacher who focuses on ‘finishing’ the lessons, to become a reflective teacher, questioning what transpired in the class and how to improve. He has deviated from being too much focused on the ‘80% index of mastery’ to giving students a chance to reason out and be able to come up with varied answers from the situation he has given in his math class: “... somehow, every day I would take [time] to recall what happened on that day, a day before. So, being somewhat reflective as I was very inspired” and he further expressed “... there is a change in myself that if the pupils could reason out, [and] then if they are able to give you different answers ... not necessarily ... you get 80% of the [index of mastery] ... I become more concerned if I have asked the right questions, ... inculcated the right concepts, ... the right activities. M4”.

The teachers also expressed that they have shared these experiences to their co-teachers in their schools and are able to take progress as a mentor to one’s colleagues. Some started their own lesson study groups and integrated them as their learning action cells which were deeply appreciated.
by their superiors. These changes in their attitudes impacted their professional and personal growth as well.

4.2. Impact on Professional and Personal Growth
The teacher-participants also took the professional skills scale survey. The teachers agree greatly that they have such skills, with conducting research being the lowest skills agreed upon by the teachers. Among the skills mentioned, the teachers agree most with the statement “After the Project STAR training, I am able to critically analyze the strengths and weaknesses of my teaching practices. S1”; “… acknowledge that seeking advice and giving collegial advice are desirable skills in improving teaching skills. S3”; “… test new ideas and adapt to changes in the practice. S4” This can be related to the benefits expressed by some respondents in the FGD on being more reflective, being more patient, more open on dealing with their students. However, there is a challenge towards being able to “… build a group of professional community who frequently discusses practices and student progress. S5”; “… conduct research on science teaching and learning. S6” and “… actively participate in a group organized as an offshoot of the Project STAR training. S7” In support to the survey, the FGD participants verified through their experiences that such skills were developed. In particular, a teacher expressed her growth as a better mentor: “I have grown much better colleague and how to mentor my co-teacher … M3” In response to the teachers’ efforts to improve the teaching practice in their respective schools, some teachers accepted such approaches in teaching: “[colleagues] are open as they liked the idea of the students being able to reason out … they agree with me even if they are my seniors … because of the strategy. M4”

Amidst the success and improvements of these select teachers experienced in their various implementation and endeavors, they are still faced with many limiting factors. Considering the highlights in the teaching practices survey and the professional skills survey, indeed there are many factors that hinders the successful adaptation of the training content into everyday practice. Personal factors such as willingness and commitment have been cited by many in the FGD. Some mentioned in-placed policies on ‘explicit teaching’ being in direct opposition to the aims of the training content. Time constraint, inapplicability to some topics and even the intimidating effect of the teaching approach’s name contribute to such limitation according to the FGD participants. Finally, the lack of support and monitoring have been aired out as one of the important factors: “the [principal] is ok, but there is really no close monitoring. M5”; “… the problem ma’am is the implementation because the monitoring, there is none before… M3”

3.3. Impact on Students
The aim of the training is the development of critical thinking and problem-solving skills among the students. The results in the surveys and interviews are verified by observing the classes of those select FGD participants. Based on the FGD, the teachers expressed that they have seen the effects of their implementation to the students:

![Figure 4. Perceived benefits of the training to the students](image)

The FGD participants have witnessed, that their students have shown good collaboration among group members as they have activities, even collaboration between the teacher and the students (M4, M5). Students of some teachers have overcome the convention and no longer see a mathematics classroom as a threatening environment because they have been engaged in their learning activities
(M6) and they start to look for the next mathematics class which can rarely observed in other classes (M1). Because the students have improved their attitude towards the mathematics class, they also grow in confidence, in reasoning and in thinking for themselves (M1, M4). Some students also showed signs of engaging in higher order thinking as one teacher shared: “I was observed by the supervisor ... he was amazed because the pupils learned to reason out in every answer they give. M4” Another teacher also noted “... although their reasoning is farfetched, if processed, they say ‘Ah, yes sir! That is what I meant.’ M2”. Finally, one teacher claimed that her students were able to bridge the content and context of the real-life situation (M3). Although such claims cannot be generalized, it would show that there is change and improvement among the learners.

Upon interviewing the students in the respective classes of those selected from the FGD, the following insights were drawn from the student responses:

- There is evidence by existence that the students really benefited from the pedagogies practiced. Such benefits include Confidence in reasoning/answering, Critical thinking, and Improved attitude towards the subject. [M3, M6 classes]
- There is also evidence that the pedagogies promoted by the STAR trainings have been applied in the regular classroom setting. In particular, the mostly cited strategy utilized in the classroom is contextualization of the lesson. Furthermore, most students interviewed thought that the teachers under observations often asks questions that really made them think in their regular classes [M3, M5, M6 classes].

5. Conclusion and Recommendations

Project Science Teacher Academy for the Regions (STAR) proved to have impacted the teaching practices of teacher participants. Even if not all the teacher participants have implemented the promoted approach, TMPS, those who proficiently implemented in their class showed particular gains both in their teaching practice, professional skills and students. The survey in conjunction with FGD and the student and supervisor interviews during classroom observations showed that there is a positive change of paradigm in teachers’ beliefs and practice. The changes bringing about the shift in the role of the teacher, such as focusing on giving key questions, ‘processing’ student ideas and guiding students, conforms to the characterization of [14] as he describes the role of teachers in a typical Japanese mathematics class, of where TMPS is derived from. The training helped the teachers on how to teach the mathematics, that is pedagogical content knowledge (PCK), but data on teachers’ domain-specific content knowledge (CK) have yet to be tapped in this evaluation study. [7] noted in their study that PCK and CK form a function to the degree of expertise of a teacher, hence the need for further investigation.

Students being the end-recipients of these benefits indicated by the positive changes in their attitudes and behavior inside the classroom. These results show the potential of TMPS in developing what the Mathematics Education framework aims to achieve, which is the critical thinking and problem-solving skills. These results from the evaluation study confirms that of [18] that a good combination of the training components maximizes its effectiveness. The challenge of having consistent and careful feedback from their supervisors also conforms to the claim of [18] as feedback, both structured and open-ended and coaching are components necessary to increase the effectiveness of in-service training. While there are encouraging changes in practice, based on Kirkpatrick’s Training Evaluation Model, the training’s impact has yet to fully reach a considerable organizational change in the region.

Hence, based on the results, it is highly recommended that policies enabling joint monitoring of the school administrators and the partner universities may be put in place to further collaboration in the improvement of the teaching practice. This includes the strengthening of the school-based professional development strategy through establishing a community of learners like a ‘school within a school’ [18] for the teachers. The possible effect of the differences of the teachers’ CK to their implementation may also be investigated further. Finally, to verify the significance of the student gains, a more rigorous longitudinal study may be conducted.
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APPENDIX 1

Teaching Practices Survey Statements
1. I integrate scientific and mathematical learning goals and objectives to other disciplines.
2. I do NOT relate the topic to other disciplines.*
3. I include topics of other disciplines that relate to the subject matter.
4. I use real-life context to make learning more meaningful.
5. I consider prior knowledge and experiences of my students in teaching.
6. I provide concrete examples to make connections with the students’ personal experiences.
7. I discuss the subject matter at hand without relating to other fields.*
8. I make sure that the topic is well understood by giving relevant situations.
9. I include demonstrations and activities that require skills and knowledge from more than one discipline.
10. I follow totally what is in the reference book when discussing a topic.*
11. I utilize local events, places and materials to enhance my teaching and the learning experiences of my students.
12. I use real-life situations in assessing learning objectives.
13. I am part of a small group of teachers who collaborate to improve a lesson.
14. I observe and document how a particular lesson and its method affect the learning of my students.
15. I study more on the content of a lesson but not so much on how it will affect learning.*
16. I assume that a lesson plan is effective because I have been using it for a long time.*
17. I use the findings of research lessons to develop and refine my own lesson plans.
18. I collaborate with other teachers in evaluating, developing and innovating instructional materials appropriate to the learner’s needs.
19. I appreciate comments and suggestions to improve the lesson.
20. I use old lesson plans again and again without modifications.*
21. I encourage my students to memorize concepts than to ask questions.*
22. I design learning experiences that challenge the problem solving ability of my students.
23. I engage students in investigation to develop their critical thinking skills.
24. Most of the time, I do the talking in class.*
25. I use a teaching method that develops learner’s divergent thinking.
26. I let students reflect on the consequences of their decisions.
27. I allow students to make decisions based on independent judgement.
28. Most of the questions in the test I give to my students require rote memory.*
29. I usually start the class by presenting situations that stimulate students’ thinking.
30. I ensure that science/math concepts learned are related to real-life experiences.

*Negative statements

Professional Skills Survey Statements
After the STAR training I am able to:
1. [critically analyze the strength and weaknesses of my teaching practices]
2. [gather evidences about student learning to evaluate teaching effectiveness]
3. [acknowledge that seeking advice and giving collegial advice are desirable skills in improving teaching skills]
4. [test new ideas and adopt to changes in the practice]
5. [build a group of professional community who frequently discusses practices and student progress]
6. [conduct research on science teaching and learning]
7. [actively participate in a group organized as an offshoot of the Project STAR training]
8. [establish professional relationship with colleagues who share the same interest in improving science and math teaching and learning]