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A Project Monitoring Study on the Improvement of Elementary Science Teacher's Science Teaching Efficacy through a Flexible Online Training Course

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Abstract

The curricular revamp in the Philippine's Basic Education aimed to improve the learning outcomes of Filipino Students. In science education, this revision in the curriculum posed a mismatch in the past teacher preparation and current basic education science education curriculum. As a response, a flexible training program was conducted to address this curriculum gap. This study investigated the improvement of science teaching efficacy utilizing rapid project monitoring through a pre-experimental research design. Standardized adopted questionnaires were utilized before and after the training program. At the end of the training program, teachers were found to have improved in all aspects of science teaching efficacy except in the personal science teaching efficacy, which indicates success in achieving the training objectives. In addition, all targeted concepts for science teaching efficacy were improved after the training. The results of this present work support the notion that professional development programs are potential ways to address curricular gaps in teacher and curriculum mismatch. It is recommended that further studies be conducted to examine science teachers' experiences during the training program to understand how it contributes to the development of their science teaching efficacy.

Keywords: professional development program, science curriculum, science teaching, teacher training, teaching efficacy

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Introduction

Teacher self-efficacy has been defined as the teacher's beliefs about their ability to teach, manage the classroom, and motivate their students to learn (Tschannen-Moran & Hoy, 2001; Walag, Fajardo, Guimary & Bacarrisas, 2020). It influences how a teacher thinks, feels, motivates, and acts (Zulkosky, 2009). In the classroom environment, this efficacy controls the teacher's activities and behaviors, their persistence, particularly with students who have difficulties in learning, and their effort towards teaching (Moslemi & Mousavi, 2019). In addition, teaching efficacy is a critical force in teacher development and a strong influence on teachers' professional practices, student learning outcomes, and the management of meaningful teaching and learning activities (Klassen & Tze, 2014; Norris, Morris & Lummis, 2018).

A good number of studies support teachers' self-efficacy is related to student learning outcomes (Caprara, Barbaranelli, Steca & Malone, 2006; Muijs & Reynolds, 2015). Teachers who have high self-efficacy tend to create supportive and motivational classrooms that lead to students' higher learning outcomes (Mojavezi & Tamiz, 2012). From the student's point of view, teachers with high levels of self-efficacy are more likely to consider student's differences in their teaching and are more willing to learn and implement various teaching strategies to meet their students' needs (Fackler & Malmberg, 2016; Gabriele & Joram, 2007; Walag, Fajardo, Bacarrisas & Guimary, 2020). Although many papers have highlighted the link between teacher efficacy and student outcomes, several reports also found no correlation between the two, making this link inconclusive (Digal & Walag, 2019; Mahler, Großschedl, & Harms, 2017). Although the debate is still on whether teacher efficacy directly impacts student outcomes, it is still worthwhile to examine how teachers develop teaching efficacy (Walag, Fajardo, Bacarrisas, & Guimary, 2022).

An increasing number of studies have highlighted that professional development programs aim to alter negative perceptions of science teachers and address knowledge deficiencies. For example, a study highlighted the impact of teacher professional development programs on teacher's belief systems (Zan & di Martino, 2020), student learning and teaching practices, and the benefits of the program on the scientific investigation and discovery process (Fazio, di Paola & Battaglia, 2020). Another study also highlighted how an online flexible online training course develops high school science teachers' science teaching efficacy (Bug-os, Besagas, Gabunilas & Walag, 2021). Although several studies have elucidated the possible link between teacher professional development and improvement of teaching efficacy, much of these are on pre-service teachers. The authors hypothesize that the same professional development programs can also benefit in-service teachers.

With these premises, the researchers conducted a needs-analysis of the personal science teaching efficacy and subject-specific self-efficacy of in-service public elementary science teachers of Cagayan de Oro City and El Salvador City. Based on the results, a flexible online training course was developed to improve their self-efficacy in teaching topics they identified to have the least confidence in teaching. The training course was conducted for eight weeks through an online learning platform. Synchronous (i.e., video conferencing for live discussions, online lecture) and asynchronous (i.e., online module, worksheets, online simulations, reading materials, recorded lecture) classes were provided to maximize learning. The flow of the study is summarized

in Figure 1. As part of monitoring and evaluation of the quality and success of the project, this study was conducted. The main objective of this research is to evaluate the project's success in improving elementary science teachers' personal science teaching efficacy and subject-specific self-efficacy due to their participation in a flexible online training course.

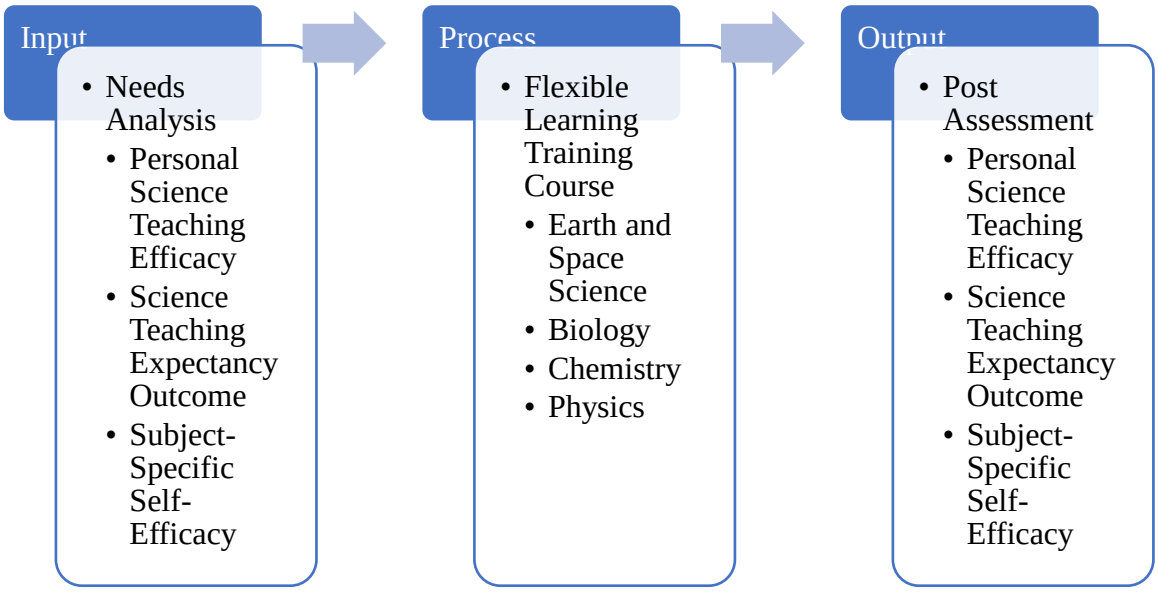

Figure 1. Schematic diagram showing the flow of the study

Methods

This present study utilized a rapid project monitoring design through a pre-experimental research design, particularly a one-group pretest-posttest design, to determine the improvement of elementary science teachers' science teaching efficacy (Bug-os, Besagas, et al., 2021; Walag & Fajardo, 2020). In this study, pretest and posttest are both taken, but no control group to compare the experimental group to. The training course was participated by elementary school science teachers from Cagayan de Oro City (N=90) and El Salvador City (N=70), who registered two weeks before the official start of the course. At the end of the online course, 66 teacher-participants successfully completed and were considered as the sample for this study. The demographics of the teacher-participants are summarized in Table 1.

Table 1: Elementary Science Teachers' Profile of the Division of Cagayan de Oro City and El Salvador City (n=66)

Parameter		Frequency
Gender		
	Male	7
	Female	58
	Prefer not to say	1
Science Level Taught		
	3	21
	4	10
	5	16
	6	19
Position		
	Teacher 1	50
	Teacher 2	5
	Teacher 3	7
	Master Teacher 1	4
Educational Qualification		
	Bachelor's	51
	Master's	15

Before data collection and training, permission was acquired from the Department of Education Division of Cagayan de Oro City and El Salvador City. Several coordination meetings were conducted to design and plan the flexible online training course with the assistance of the Division Office's Education Program Supervisor in Science. The personal aspect of self-efficacy towards science teaching, comprising of the personal science teaching efficacy (PSTE) and the science teaching outcome expectancy (STOE), was determined using Science Teaching Efficacy Belief Instrument (STEBI) modified by Bleicher (2004). The subject-specific self-efficacy (SSSE) was assessed using the instrument developed by Walag et al. (2020), which was based on the competencies enumerated in the K to 12 Curriculum Guide of the Department of Education. The improvement in teachers' personal and subject-specific self-efficacy was determined using a dependent t-test at 0.05 level of significance.

The confidentiality and anonymity of participants' responses were given the highest priority in this study. All necessary measures were taken to ensure that the participants were not harmed in any aspects or parts of this project (Casino & Walag, 2022; Walag et al., 2018). The objectives were clearly ex-

plained in an orientation before the conduct of the study, and that participation was voluntary. All methods, instruments, and procedures were reviewed and approved by the University's Research Office and Extension and Community Relations Office.

The focus of the flexible online training program was on the development of science content knowledge as it is hypothesized to affect teachers' self-efficacy. Thus, Table 2 summarizes the pre-identified topics through the prior needs-analysis.

Table 2: Topics Covered in the Flexible Online Training Program

Subject	Cagayan de Oro City*	El Salvador City*
Earth Science	Constellations and the information derived from their location in the sky The phases of the Moon and the beliefs and practices associated with it Components of weather using simple instruments	Constellations and the information derived from their location in the sky The phases of the Moon and the beliefs and practices associated with it Weather patterns and seasons in the Philippines
Biology	Interactions for survival among living and non-living things that take place in estuaries and intertidal zones Reproduction of non-flowering plants Interactions for survival among living and non-living things that take place in tropical rainforests, coral reefs, and mangrove swamps	Reproduction among humans, animals, and plants and certain observable characteristics that are passed from parents to offspring Reproduction of non-flowering plants The major organs of the human body and how they work together to form organ systems
Chemistry	Materials undergo changes due to oxygen and heat Different types of mixtures and their characteristics Different techniques to separate mixtures	Materials undergo changes due to oxygen and heat Different types of mixtures and their characteristics Different techniques to separate mixtures
Physics	A simple DC circuit and the relationship between electricity and magnetism in electromagnets Motion in terms of distance and time Gravity and friction affect movement of objects	A simple DC circuit and the relationship between electricity and magnetism in electromagnets How energy is transformed in simple machines Gravity and friction affect movement of objects

*Taken from the Philippine's K to 12 Science Curriculum Guide

Results and Discussion

Personal Science Teaching Efficacy and Subject-Specific Science Teaching Efficacy

One of the primary goals in the curriculum revamps of the Philippine's Basic Education as mandated by Republic Act 10533 or the Enhanced Basic Education Act of 2013 is the improvement of student science learning (Bug-os and Besagas, et al., 2021). With this landmark legislation, science as a subject was overhauled in terms of the progression of topics. In this current curriculum, science is now taught using a spiraling progression approach (Bug-os, Walag & Fajardo, 2021; Valin & Janer, 2019; Walag, Fajardo, Guimary et al., 2020). In this setup, the scope and sequence of contents are developed such that concepts and skills are revisited at every grade level to build mastery from one level to another (Walag, Fajardo, Guimary et al., 2020). A significant problem with this development is that current science teachers in the field are products of the old teacher education curriculum where they have specialized science degrees (i.e., biological sciences, physical sciences, etc.) instead of a general science education degree. This highlights the mismatch between the current in-service teacher and the current science basic education curriculum. Most of the teacher education institutions in the country have revised their curriculum since 2017 and even until now, offering a general science education curriculum instead of the specialized science education degrees. This is also in compliance with the Commission on Higher Education (CHED) Memorandum Order #75 series of 2017. Although this is an excellent attempt to address this curricular gap, the qualification of the current science teachers remains a challenge. In response to this concern, the researchers conducted a project intending to improve science teachers' science teaching efficacy through an online flexible training program. The improvement results in the different science teaching efficacy parameters are summarized in Table 3.

Table 3: Improvement in Science Teaching Efficacy Parameters after the Flexible Online Training Program

Efficacy Parameter	Pre-test Mean	Post-test Mean	t (df)	p-value
Personal Science Teaching Efficacy (PSTE)	40.38	42.24	-1.88 (65)	0.06
Science Teaching Outcome Expectancy (STOE)	30.56	32.30	-2.95 (65)	0.00*
Earth and Space Science Efficacy (ESSE)	50.55	54.08	-3.12 (65)	0.00*
Biology Efficacy (BE)	63.35	67.5	-2.85 (65)	0.00*
Chemistry Efficacy (CE)	33.17	35.71	-3.21 (65)	0.00*
Physics Efficacy (PE)	31.45	35.12	-4.85 (65)	0.00*

*Significant at 0.05 level

All efficacy parameters were improved after the flexible online training program except PSTE, as shown in Table 3. The result in PSTE is expected as the focus of the training program was the development of subject-specific efficacy and not on science teaching pedagogy. This result is also similar to the results found in Bug-os et al. (2021), where high school teachers trained in flexible online training also did not develop PSTE and STOE. In the work of Bracey et al. (2013), PSTE and STOE were significantly improved as the training was focused on inquiry-based and problem-centered pedagogies. Another similar report found improvement in teacher efficacy due to professional development (Fabriz et al., 2020). These contrasting results in the literature highlight a divide in how professional development programs impact teacher self-efficacy. This result also cements that personal science teaching efficacy is relatively stable after teacher induction years (Lotter et al., 2018).

The development of STOE is surprising as teachers did not have "classroom experience" in this professional development training. Most of their time interacting with facilitators was limited to simulations, videoconferencing, and online modular activities. Thus, it is surprising since it has been well accepted that field experience is a valuable opportunity for students to develop pedagogical knowledge from their classes (Beeth & Adadan, 2006). One probable reason for this improvement is the immediate feedback provided to participants as the online flexible training program utilized an e-learning platform where facilitators and participants can engage interactively. As previously reported, immediate feedback and thoughtful planning allow teachers to observe students learning through inquiry, which in turn develops teachers' STOE.

Improvements in Subject-Specific Science Efficacy

An item-wise comparison was also conducted to identify which specific science content areas the participants were found to have improved on. As shown in Table 4, the different concepts for earth and space science contents were compared. Significant improvements were seen in concepts 3, 6, 9-11, and 13. The improvement in these concepts in ESSE is expected as these were the target concepts in training, as reflected in Table 2. This suggests the success in achieving the objectives of the online training.

Table 4: Item-wise Comparison of Earth and Space Science Efficacy

Concepts	p-value
1. People, animals, plants, lakes, rivers, streams, hills, mountains, and other landforms, and their importance	0.22
2. Types and effects of weather as they relate to daily activities, health, and safety	0.05
3. Natural objects in the sky affect one's daily activities	0.00*
4. Different types of soil	0.05
5. Different sources of water suitable for human consumption	0.09
6. Components of weather using simple instruments	0.00*
7. The sun as the main source of heat and light on Earth	0.12

8. Weathering and soil erosion shape the Earth's surface and how these affect living things and the environment	0.05
9. Weather disturbances and their effects on the environment	0.03*
10. The phases of the Moon and the beliefs and practices associated with it	0.00*
11. Constellations and the information derived from their location in the sky	0.00*
12. The effects of earthquake and volcanic eruptions	0.05
13. Weather patterns and seasons in the Philippines	0.02*
14. Earth's rotation and revolution	0.08
15. Characteristics of planets in the solar system	0.09

*Significant at 0.05 level

Table 5 reflects the item-wise comparison of the improvement in biology efficacy in specific concepts before and after the online training program. As highlighted, improvement was found in concepts 2, 5, 11-15, and 17-19. The improvements in concepts 5, 11, 15, and 17-19 are not surprising as these were the targeted concepts in training. This improvement is an indicator of the success in attaining the objective of the online training program. The improvement in concepts 2 and 11-14 is not surprising, even if these were not part of the pre-identified topics. These concepts can be considered closely related to the topics covered in training. Although this improvement was not intended, the outcome is still desirable since science should be interdisciplinary taught by allowing students to see the whole picture of the concepts, build links among central topics, and form more profound and fundamental understanding (Czerniak & Johnson, 2014).

Table 5: Item-wise Comparison of Biology Efficacy

Concepts	p-value
1. Parts, and functions of the sense organs of the human body	0.05
2. Parts and functions of animals and importance to humans	0.00*
3. External parts of plants and their functions, and importance to humans	0.05
4. Characteristics of living and nonliving things	0.07
5. Reproduction among humans, animals and plants and certain observable characteristics that are passed from parents to offspring	0.02*
6. Basic needs of plants, animals and humans	0.05
7. Major internal organs such as the brain, heart, lungs, liver, stomach, intestines, kidneys, bones, and muscles	0.30
8. Body parts of animals that make them adapt to land or water	0.20
9. Body parts of plants that make them adapt to land or water	0.06
10. Life cycle of different organisms and the effects of their environment	0.05
11. Beneficial and harmful interactions occur among living things and their environment as they obtain basic needs	0.03*

12. Parts of the human reproductive system and how it works	0.01*
13. Animal reproduction	0.02*
14. Plant reproduction	0.01*
15. Interactions for survival among living and non-living things that take place in estuaries and intertidal zones	0.00*
16. Different characteristics of vertebrates and invertebrates	0.13
17. Reproduction of non-flowering plants	0.00*
18. Interactions for survival among living and non-living things that take place in tropical rainforests, coral reefs, and mangrove swamps	0.04*
19. The major organs of the human body and how they work together to form organ systems	0.00*

*Significant at 0.05 level

Table 6 shows the item-wise comparison for the improvements in the specific concepts in chemistry efficacy before and after the training program. As shown, the efficacy improved in all concepts except in concepts 3 and 5. The improvement in most of the efficacy in these chemistry concepts is expected as all of these are related to the topics covered in the training program. Similar to other areas, these results indicate success in achieving the training's objectives. In addition, this result also supports that when professional development training is content-specific, the development of some related concepts is expected as science has an interdisciplinary nature (Raan, 2018).

Table 6: Item-wise Comparison of Chemistry Efficacy

Concepts	p-value
1. Ways of sorting materials and describing them as solid, liquid, or gas based on observable properties	0.04*
2. Effects of temperature on solids and liquids	0.00*
3. Grouping different materials based on their properties	0.07
4. Proper handling of waste material, and proper storage and safekeeping of useful/harmful materials	0.01*
5. Methods of grouping different materials that can be recycled, reduced, reused, recovered, and repaired	0.05
6. Changes that materials undergo when exposed to certain conditions	0.02*
7. Properties of materials to determine whether they are useful or harmful	0.04*
8. Materials undergo changes due to oxygen and heat	0.00*
9. Different types of mixtures and their characteristics	0.00*
10. Different techniques to separate mixtures	0.00*

*Significant at 0.05 level

Finally, the item-wise comparison of physics efficacy before and after the online training program is summarized in Table 7. As shown, the participants were found to have improved physics efficacy in all concepts, whether covered or not covered in training. The improvement of efficacy in other areas not covered in training is a desirable outcome as this suggests that facilitators may be able to link concepts with other related concepts providing a more holistic approach in teaching physics concepts.

Table 7: Item-wise Comparison of Physics Efficacy

Concepts	p-value
1. Motion of objects	0.00*
2. Sources and uses of light, sound, heat and electricity	0.04*
3. Force that can change the shape, size or movement of objects	0.02*
4. How light, heat and sound travel using various objects	0.00*
5. Motion in terms of distance and time	0.00*
6. How different objects interact with light and sound, heat and electricity	0.00*
7. The effects of heat and electricity, light and sound on people and objects	0.00*
8. A simple DC circuit and the relationship between electricity and magnetism in electromagnets	0.00*
9. Gravity and friction affect movement of objects	0.00*
10. How energy is transformed in simple machines	0.00*

*Significant at 0.05 level

Conclusion

This project monitoring study was conducted to investigate the improvement of science teaching efficacy of elementary science teachers as an output of a flexible online training program. As a result of the training, all areas in science teaching efficacy were found to have improved except in the personal science teaching efficacy area. This is expected as this has been found in the literature to be relatively stable and require opportunities for teachers to do hands-on activities for it to develop. In terms of their subject-specific self-efficacy, elementary teachers were found to have improved in all areas, which indicates the success in achieving the objectives of the training program. In addition, all concepts targeted in the training program were found to have improved after the training. The results of this present work support the notion that professional development programs are potential ways to address curricular gaps in teacher and curriculum mismatch. It is recommended that further studies be conducted to examine the roles of professional development programs in developing ‘teachers' science teaching efficacy qualitatively.

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