IMPROVING HIGH SCHOOL TEACHER'S SUBJECT-SPECIFIC SCIENCE TEACHING EFFICACY THROUGH A FLEXIBLE ONLINE TRAINING COURSE: A PROJECT MONITORING STUDY

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ABSTRACT: *Improving student science learning is one of the primary goals of the Philippine's Basic Education curriculum revamps. One primary concern with this revision is that teachers teaching science have specialized science degrees instead of generalized science degrees. This study examined the improvement of subject-specific science teaching efficacy of science teachers as an effect of a flexible online training program. A rapid project monitoring through a pre-experimental research design was utilized in the study to determine the improvement of science teaching efficacy after a flexible online training program intervention. After the training program, teachers were found to improve in all subject-specific science teaching efficacy constructs, which suggests the success in achieving the training objectives. More so, all targets specific concepts covered in the training program were improved after the training. The results of the study support the notion that professional development programs can help address the curricular gap in teacher and curriculum mismatch. It is recommended that further studies be conducted in examining the roles of a professional development program in developing the teacher's self-efficacy. Professional development programs may be undertaken to help improve teachers' confidence in teaching topics outside their specialization.*

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

1. INTRODUCTION

Self-efficacy is defined as people's beliefs about their capabilities to perform designated levels of execution that exercise influence over events that impact their lives [1]. It influences how a particular individual thinks, feels, motivates, and acts [2]. According to the social cognitive theory, self-efficacy beliefs are the strongest predictors of human motivation concerning behavior [3]. Teaching efficacy has recently emerged as a vital construct in teacher education over the past decades [4], although there is no consistent definition of this construct [5]. Teaching efficacy beliefs have been shown to be a critical factor in teacher development and a strong influence on teachers' professional practices, student learning outcomes, and the implementation of meaningful and relevant teaching strategies [6,7].

Research shows that teachers' beliefs are powerful tools in directing classroom actions as well as influencing teachers' curricular planning, instructional decisions, and professional practices and habits [8]. Beliefs have been shown to have a powerful impact on teachers' actions and consequently on student outcomes [8]. In addition, teaching efficacy was found to be positively related to student achievement and learning outcomes [9]. Due to this highlighted importance of teaching efficacy towards student outcomes and instructional practices, studies evaluating science teaching efficacy of in-service teachers have been conducted [10, 11].

A growing body of literature has elucidated that professional development programs targeting science teachers can successfully alter negative perceptions and address knowledge deficiencies. Many studies have highlighted the impact of teacher professional development programs on teacher belief systems [12], student learning and teaching practices, and the benefits of programs on developing scientific investigation and discovery processes [13]. Much of the studies on professional development programs and teaching efficacy are limited to pre-service teachers. The authors believed that programs targeting improvement in teachers' content knowledge and teaching efficacy could also benefit in-service teachers.

With these premises, the authors conducted an initial assessment of the personal science teaching efficacy beliefs and subject-specific self-efficacy of in-service public school science teachers of Cagayan de Oro City and El Salvador City. Based on the needs assessment, a flexible online training course was designed aimed at improving their self-efficacy in teaching topics they identified to be least confident in. The training course was conducted for eight weeks through an online learning platform. Synchronous (i.e., video conferencing for live discussions) and asynchronous activities (i.e., modules, worksheets, online simulations, reading materials, and recorded video lectures) 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 primary objective of this research is to evaluate the project's success in improving high school science teachers' personal science teaching efficacy and subject-specific self-efficacy due to their participation in a flexible online training course.

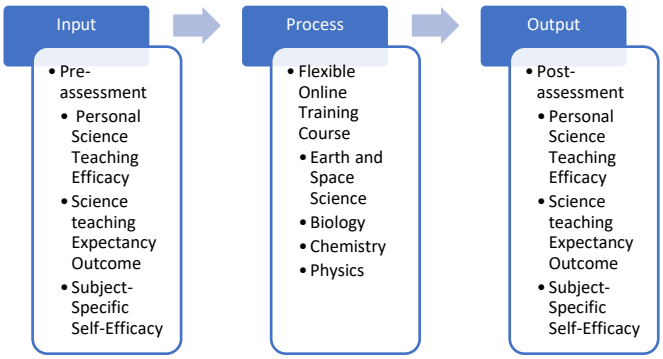

Figure 1. Schematic Diagram showing the flow of the study

2. MATERIALS AND METHODS

This study utilized rapid project monitoring through a pre-experimental research design, particularly a one-group pretest-posttest design, to determine the improvement of science teachers' science teaching efficacy [14, 15]. 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 high school science teachers from Cagayan de Oro City (N=101) and El Salvador City (N=25), who registered two weeks before the official start of the

course. At the end of the online course, 75 teacher-participants successfully completed and were considered as the population for this study where the sample (n=45) was taken from. The demographics of the teacher-participants are summarized in Table 1.

Prior to data collection and conduct of training, permission was acquired from the Department of Education Division of Cagayan de Oro City and Division of 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 [16]. The subject-specific self-efficacy (SSSE) was assessed using the instrument developed by Walag et al. [11], 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 measured using a paired t-test at 0.05 level of significance.

Table 1. Science Teachers' Profile of the Division of Cagayan de Oro City and El Salvador City (n=45)

Parameter		Frequency
Gender		
	Male	3
	Female	42
Science Level Taught		
	7	10
	8	12
	9	11
	10	12
Position		
	Teacher 1	30
	Teacher 2	2
	Teacher 3	11
	Master Teacher 1	2
Educational Qualification		
	Bachelor's	33
	Master's	12

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. The objectives were clearly explained 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 have an effect on teachers' self-efficacy. Thus, Table 2 summarizes the topics that were pre-identified 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	Characteristics of comets, meteors, and asteroids	Characteristics of comets, meteors, and asteroids
	The relationship between the visible constellations in the sky and Earth's position along its orbit	The relationship between the visible constellations in the sky and Earth's position along its orbit
	The relationship among the locations of volcanoes, earthquake epicenters, and mountain ranges	
Biology	Meiosis is one of the processes producing genetic variations of the Mendelian Pattern of Inheritance	The structure and function of mitochondrion as the main organelle involved in respiration
	How genetic information is organized in genes on chromosomes	The information stored in DNA as being used to make proteins
	How changes in a DNA molecule may cause changes in its product	
Chemistry	The unit, mole, that quantitatively measures the number of very small particles of matter	The identity of a substance according to its atomic structure
	The structure of biomolecules, which are made up mostly of a limited number of elements, such as carbon, hydrogen, oxygen, and nitrogen	The particle nature of matter as a basis for explaining properties, physical changes, and structure of substances and mixtures
	The chemical reactions associated with biological and industrial processes affecting life and the environment	How gases behave based on the motion and relative distances between gas particles
Physics	Projectile motion, impulse and momentum, and conservation of linear momentum	Charges and the different charging processes
	The different regions of the electromagnetic spectrum	Current-voltage resistance relationship, electric power, electric energy, and home circuitry
	The relationship between electricity and magnetism in electric motors and generators	Generation, transmission, and distribution of electrical energy from power plants to home

*Based on Philippine's K to 12 Science Curriculum Guide

3. RESULTS AND DISCUSSION

Personal Science Teaching Efficacy and Subject-Specific Science Teaching Efficacy

Improving student science learning is the primary goal of the curriculum revamps of the Philippines's Basic Education as mandated by Republic Act 10533 or the Enhanced Basic Education Act of 2013. Through this landmark legislation, science, as a subject, underwent major revision. The different science concepts are now taught using a spiraling progression approach where the scope and sequence of contents are developed such that concepts and skills are revisited at each grade level to allow mastery from one level to another [11, 17]. One major concern with this revision is that teachers teaching science have specialized science degrees instead of having a generalized science degree. This highlights the mismatch between the training of in-service teachers and the current science curriculum. Most of the teacher education institutions revised their curricula for science teaching as a response to this. Although this is an excellent attempt to address curricular gaps, the in-service teachers who are products of the old curriculum still remain a challenge. As a response to this, a project was organized to improve science teachers' efficacy in teaching science through flexible online learning training. The results of the improvement in the different science teaching efficacy parameters are summarized in Table 3.

In terms of their PSTE and STOE, no significant difference was found in the mean scores before and after the flexible online training. This result is expected since the focus of the intervention program was on science content and not a science teaching pedagogy. Unlike in the work of Bracey et al. [18], PSTE and STOE significantly improved when participants were trained with the emphasis on inquiry-based and problem-centered pedagogies. Another similar report also highlighted an improvement in teacher self-efficacy due to a teacher professional development program [19]. This suggests a divide in the literature in how professional development programs impact teacher self-efficacy. As previously reported, teacher education programs, as a whole, do not appear to influence science teaching efficacy but rather influence their beliefs on student epistemology and ability to learn science [20]. More so, the findings of this study support the notion that personal self-efficacy is relatively stable after teacher induction years [21, 22].

Further, the absence of significant difference in STOE seems logical. These teachers did not have "classroom experience" in this professional development training; much of their facilitators' interaction was limited to simulations, limited videoconference lectures, and modular activities online. It has been well accepted that field experience is a valuable vehicle for students to acquire pedagogical knowledge from their classes [23]. More so, practice teaching, immediate feedback, and thoughtful planning allow teachers to observe students learning through inquiry, which helps develop teachers' STOE [22]. Although the project hoped to improve both PSTE and STOE due to the science content training, this was not achieved due to the limitation of a "real classroom experience" where participants can see face-to-face how science should be taught.

Table 3. Comparison of different science teaching efficacy parameters before and after the training course

Efficacy Parameter	Pre-test Mean	Post-test Mean	t (df)	p-value
Personal Science Teaching Efficacy (PSTE)	41.67	42.22	-0.74 (44)	0.46
Science Teaching Outcome Expectancy (STOE)	29.80	30.27	-0.98 (44)	0.33
Earth and Space Science Efficacy (ESSE)	35.91	37.67	-3.52 (44)	0.00*
Biology Efficacy (BE)	90.16	96.82	-5.31 (44)	0.00*
Chemistry Efficacy (CE)	50.42	54.02	-5.15 (44)	0.00*
Physics Efficacy (PE)	57.98	62.02	-4.60 (44)	0.00*

*Significant at 0.05 level

Improvements in Subject-Specific Science Efficacy

Item-wise comparison was also conducted to identify how the training program improved science teachers' teaching efficacy in specific science content. Table 4 shows the item-wise comparison for Earth and Space Science contents. As shown, significant improvements were noted in concepts 3, 5, 7, 10, and 11. The improvement in their ESSE for concepts 7, 10, and 11 is expected as these are the target concepts of the training program, which indicates the success in achieving the training objective. Meanwhile, the improvement in concepts 3 and 5 is not surprising as although they were not part of the pre-identified topics, these concepts are very closely related to concepts 7, 10, and 11. This suggests that the improvement for these concepts is not an intended outcome but desired as science should be interdisciplinary taught by allowing students to see big-picture concepts, build connections among central concepts, and form deeper and fundamental understanding [25].

Table 4. Item-wise comparison of Earth and Space Science Efficacy

Concepts	p-value
1. Relationship of the geographical location of the Philippines to its environment	0.05
2. Different phenomena that occur in the atmosphere	0.17
3. Relationship of the seasons and the position of the Sun in the sky	0.02*
4. The occurrence of eclipses	0.37
5. Relationship between faults and earthquakes	0.00*
6. The formation of typhoons and their movement within the PAR	0.32
7. Characteristics of comets, meteors, and asteroids	0.00*
8. Volcanoes found in the Philippines	0.26
9. Factors that affect climate, and the effects of changing climate, and how to adapt accordingly	0.25
10. The relationship between the visible constellations in the sky and Earth's position along its orbit	0.00*
11. The relationship among the locations of volcanoes, earthquake epicenters, and mountain ranges	0.01*

*Significant at 0.05 level

Table 5 shows the item-wise comparison of the improvement of biology efficacy in specific concepts before and after the training program. As shown, significant improvements are found in concepts 4, 5, 7, 9, 10, 12, 15, and 16-28. The improvements in subject-specific science efficacy for concepts 5, 9, 10, 16, 17, 19 to 26 are expected as these are covered concepts in the training program. Again, these results indicate the success of the program in achieving its objectives. The rest of the concepts that were found to be significant but not covered in the training program are also not surprising as the approach in teaching science is spiraling. These basic concepts could be developed indirectly when advanced concepts are being discussed. As biology as a subject is hierarchical, studying from organelle to biosphere level, it is expected that when a higher level topic is discussed, a review of the lower-level topics is imperative (i.e., Bérczi 2016 [26]).

Table 5. Item-wise comparison of Biology Efficacy

Concepts	p-value
1. Parts and functions of the compound microscope	0.16
2. The different levels of biological organization	0.06
3. The difference between animal and plant cells	0.07
4. Organisms that can only be seen through the microscope, many of which consist of only one cell	0.00*
5. Reproduction is both asexual or sexual	0.00*
6. Organisms interact with each other and with their environment to survive	0.13
7. The digestive system and its interaction with the circulatory, respiratory, and excretory systems in providing the body with nutrients for energy	0.02*
8. Diseases that result from nutrient deficiency and ingestion of harmful substances, and their prevention and treatment	0.00*
9. How cells divide to produce new cells	0.00*
10. Meiosis is one of the processes producing genetic variations of the Mendelian Pattern of Inheritance	0.03*
11. The concept of a species	0.17
12. The species as being further classified into a hierarchical taxonomic system	0.02*
13. The one-way flow of energy and the cycling of materials in an ecosystem	0.17
14. How the different structures of the circulatory and respiratory systems work together to transport oxygen-	0.01*

rich blood and nutrients to the different parts of the body	
15. The prevention, detection, and treatment of diseases affecting the circulatory and respiratory systems	0.03*
16. How genetic information is organized in genes on chromosomes	0.00*
17. The different patterns of inheritance	0.00*
18. How changes in the environment may affect species extinction	0.00*
19. The structure and function of plant parts and organelles involved in photosynthesis	0.00*
20. The structure and function of mitochondrion as the main organelle involved in respiration	0.00*
21. Organisms as having feedback mechanisms, which are coordinated by the nervous and endocrine systems	0.00*
22. How these feedback mechanisms help the organism maintain homeostasis to reproduce and survive	0.00*
23. The information stored in DNA is being used to make proteins	0.00*
24. How changes in a DNA molecule may cause changes in its product	0.00*
25. Mutations that occur in sex cells as being heritable	0.00*
26. How evolution through natural selection can result in biodiversity	0.00*
27. The influence of biodiversity on the stability of ecosystems	0.00*
28. An ecosystem as being capable of supporting a limited number of organisms	0.02*

*Significant at 0.05 level

Table 6 shows the item-wise comparison of the improvement of chemistry efficacy in specific concepts before and after the training program. As highlighted in the table, significant improvements were found in concepts 7 to 16. Similar to other subjects, the results confirm the success in achieving the program's objectives as these concepts were covered in training. This also highlights that even when the training content is specific, some other concepts can also be developed accidentally due to the very nature of science, interdisciplinarity [27].

Table 6. Item-wise comparison of Chemistry Efficacy

Concepts	p-value
1. Important properties of solutions	0.92
2. The properties of substances that distinguish them from mixtures	0.30
3. Classifying substances as elements or compounds	0.21
4. The common properties of acidic and basic mixtures	0.21
5. Properties of metals and nonmetals	0.05
6. The particle nature of matter as a basis for explaining properties, physical changes, and structure of substances and mixtures	0.06
7. The identity of a substance according to its atomic structure	0.00*
8. The periodic table of elements as an organizing tool to determine the chemical properties of elements	0.00*
9. The development of atomic models that led to the description of the behavior of electrons within atoms	0.00*
10.How atoms combine with other atoms by transferring or by sharing electrons	0.00*
11.Forces that hold metals together	0.00*
12.The type of bonds that carbon forms that result in the diversity of carbon compounds	0.00*
13.The unit, mole, that quantitatively measures the number of very small particles of matter	0.00*
14.How gases behave based on the motion and relative distances between gas particles	0.00*
15.The structure of biomolecules, which are made up mostly of a limited number of elements, such as carbon, hydrogen, oxygen, and nitrogen	0.00*
16.The chemical reactions associated with biological and industrial processes affecting life and the environment	0.00*

*Significant at 0.05 level

Finally, Table 7 shows the item-wise comparison of the improvement of physics efficacy in specific concepts before and after the training program. As highlighted in the table, significant advances were found in concepts 6, 12 to 17, and 19. All of these improved concepts were part of the training coverage, and the improvement highlights the project's success. It is noteworthy to mention that only in physics efficacy were improvement of distantly-related concepts not observed.

Table 7. Item-wise comparison of Physics Efficacy

Concepts	p-value
1. Motion in one dimension	0.34
2. Waves as a carrier of energy	0.06
3. The characteristics of sound	0.26
4. The characteristics of light	0.12
5. Transfer of heat	0.13
6. Charges and the different charging processes	0.04*
7. Newton's three laws of motion and uniform circular motion	0.16
8. Calculating work using constant force, power, gravitational potential energy, kinetic energy, and elastic potential energy	0.32
9. The propagation of sound through solid, liquid, and gas	0.57
10.Properties and characteristics of visible light	0.08
11.Heat and temperature, and the effects of heat on the body	0.06
12.Current-voltage resistance relationship, electric power, electric energy, and home circuitry	0.00*
13.Projectile motion, impulse and momentum, and conservation of linear momentum	0.00*
14.Conservation of mechanical energy	0.00*
15.The relationship among heat, work, and efficiency	0.01*
16.Generation, transmission, and distribution of electrical energy from power plants (hydroelectric, geothermal, wind, nuclear) to home	0.02*
17.The different regions of the electromagnetic spectrum	0.00*
18.The images formed by the different types of mirrors and lenses	0.21
19.The relationship between electricity and magnetism in electric motors and generators	0.00*

*Significant at 0.05 level

4. CONCLUSION

This program monitoring study examined the improvement of subject-specific science teaching efficacy of science teachers as an effect a flexible online training program. In terms of personal science teaching efficacy and science teaching expectancy outcome, no improvements were found as these constructs are relatively stable and require opportunities to develop science teaching pedagogy. After the training program, teachers were found to improve in all subject-specific science teaching efficacy constructs, which suggests the success in achieving the training objectives. More so, all targets specific concepts covered in the training program were found to be improved after the training. The results of the study support the notion that professional development programs can help address the curricular gap in teacher and curriculum mismatch. It is recommended that further studies be conducted in examining the roles of the professional development program in developing the teacher's personal self-efficacy. More so, professional development programs may be conducted to help improve teachers' confidence in teaching topics outside their specialization.

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