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Pedagogical Content Knowledge for Teaching Junior High School Science

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ABSTRACT

This study was follow-up research of an extension activity that enhanced the content mastery and pedagogy of Junior high school science teachers. The study aimed to 1) identify the common difficult topics encountered by teachers in their teaching of Science; 2) enhance their content mastery in difficult topics; 3) use computer applications or other innovative strategies that blended well with the content, and 4) improve the quality of teaching and learning processes in the classroom as demonstrated by fulfilling, lively classroom interactions with at least 50% of the students obtaining a standard passing mark of 75. The participants identified Physics as the most difficult science subject to teach. The teachers found these topics difficult: Optics, electricity, magnetism, and two-dimensional motion. The content mastery level of the teachers was below 75 MPS before the enhancement. It had elevated to 75 MPS after the enhancement activities. The t-test, for the difference of the raw score means, was significant at .000. Teachers obtained a satisfactory rating on computer applications and other strategies that blended well with the content. The blending brought an enthusiastic interaction in class, with at least 50% of the students getting a standard passing score of 75 MPS in the examination.

Keywords: Pedagogy, Content Mastery in Science, Science Education, Science Extension Project

INTRODUCTION

The College of Education inherently brings education to where it is most needed and reforms in teaching to keep teachers abreast of the changing times. The college is duty-bound to perform activities designed to develop and redevelop the skills to conform to the development and innovations in the field. Furthermore, being a Center of Development, the College has to be a catalyst for best practices, innovative curriculum, professional development, research, and extension in teacher education.

The implementation of the OBE-Based K-12 Curriculum mandates a growing need for teachers' professional development. Teachers' knowledge of the subject matter have to be updated and enhanced. This is to incorporate the latest findings and development in the field of teaching.

At present, the teachers assume a strategic role as both planners and mediators of learning. They not only teach content but the strategies required by that content to make learning meaningful. They design, redesign, implement lessons, and engage in critical reflective pedagogical approaches that would improve learning in the classroom with the new set of learners. Teachers, therefore, must consider the appropriateness of the methods that a certain concept can be delivered to maximize learning. They choose strategies for students to learn the content and how students can be assisted to learn better using those strategies. This is differentiated teaching. Pedagogical content knowledge (Shulman, 1986) is based on how teachers relate their pedagogical knowledge (what they know about teaching) to their subject matter knowledge (what they know about what they teach).

The extension study addressed science teachers' needs to match content knowledge with differentiated and innovative pedagogies that are necessary to improve the teaching-learning process in the classroom.

FRAMEWORK

This study adheres to the philosophy of continuous learning in education. Continuous learning is a process of learning where an individual acquires new skills and knowledge on an on-going process (Valamis.com, 2021). Teacher professionals can stay updated and competitive in their work by practicing continuous learning.

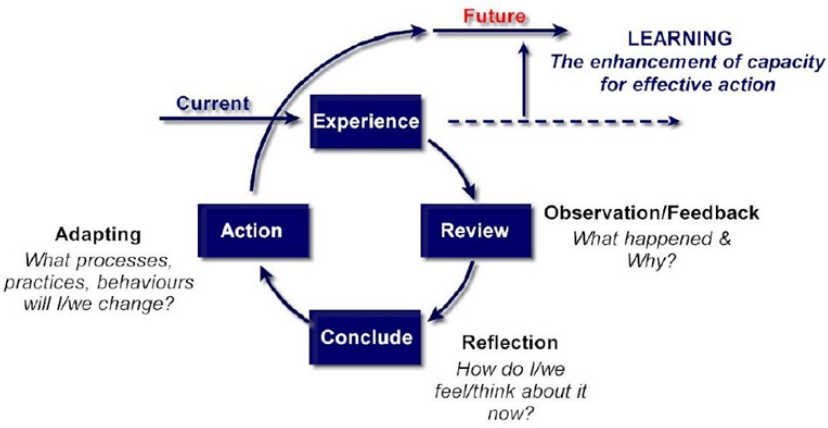

Figure 1. Model of Continuous Learning Cycle by Vanessa Welby-Solomon.

The Continuous Learning Cycle shown in this model facilitates learning and is believed to transcend the boundaries of work and deepen learning. However, using the model does not always result in a change in behavior (Welby-Solomon, 2015). A Theory of Change is beneficial to understand how continuous learning may be effective.

The Theory of Change of David Morrow helped explain the cycle and it embraced five key elements on how to manage change and produce an impact, especially in the world of learning. Change is Inevitable and Ongoing is the first element. Change happens for a myriad of reasons. It may be intentional or unintentional. Supervisors should be skillful enough to be able to step "off the dance floor" and "onto the balcony" (Heifetz & Linsky, 2002 as cited by Morrow, n.d.) to see The Big Picture. This involves the engagement of the entire organization. It is oftentimes initiated by the top but the results are driven from the bottom, the very essence of Top Down Bottom Up element. Sometimes a change will only produce a negligible effect and may remain small but if Tell Everyone is employed, a small change will produce a gargantuan leap. Significant change can happen if all stakeholders are involved, even those who are outside of the organization. Fullan (2008) said "organizations address their core goals and tasks with relentless consistency, while at the same time learning continuously how to get better at what they are doing" (p. 60). "The challenge is to move back and forth between the dance floor and the balcony, making interventions,

observing their impact in real time, and then returning to the action" (Heifetz & Linsky, 2002 p. 51). This is Continuous Learning and this makes the organization and the people in it grow (Morrow, n.d.).

Continuous professional development of teachers employs continuous learning. According to Kennedy (2005), training is the most popular and widely used model of continuous professional development. Science teachers formed a "community of practice". "A community of practice is a group of people who share a concern or a passion for something they do, and learn how to do it better as they interact regularly" (Wenger-Trayner, 2015). "Community of practice" is now replaced with a more popular term "learning community" (Kennedy, 2014).

This study re-examined and revisited the teachers' pedagogical content knowledge, teaching strategies and practices in the field. These teachers are engaged to support content learning in science and utilized different methods and strategies for students' successful learning. Despite the effort, still the performance of the learners remained low.

In this paper, the factor of low learning that is given attention to is the teacher. The community consists of the resource persons from the College of Education and the science teachers in the field who have the desire and willingness to improve their skills and knowledge in teaching science and eventually improve the performance of learners.

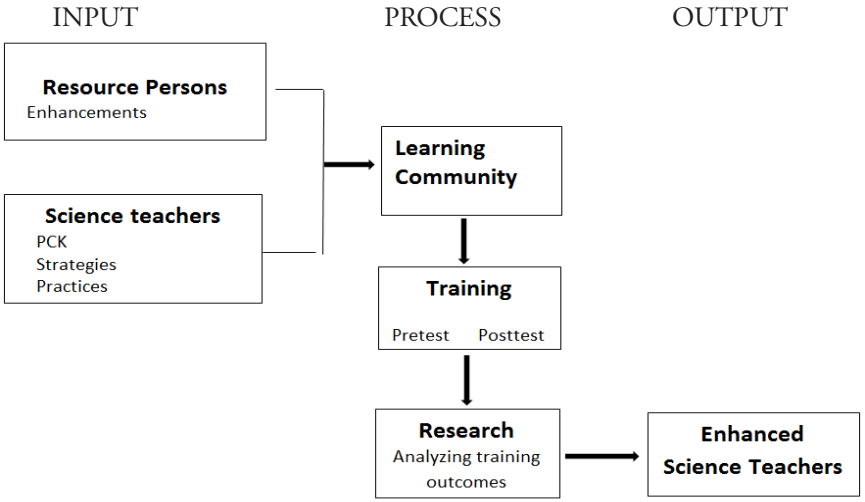

Figure 2. The Extension Paradigm.

OBJECTIVES OF THE STUDY

This research study determined the effectiveness of the extension activities that enhanced the secondary teachers' content mastery, pedagogy, and innovativeness in teaching Science. Specifically, the study resolved if participants: a) identified the common difficult topics encountered in teaching Science, b) enhanced their content knowledge mastery in the topics they found difficult to teach, c) used computer applications or other innovative approaches or strategies that blended well with the content in their science teaching, and d) improved the quality of teaching and learning processes in the classroom as demonstrated by fulfilling, lively classroom interactions with more than 50% of the students obtaining at least the standard passing mark of 75.

METHODS

The team submitted an extension proposal to conduct a study entitled "Teachers' pedagogical content knowledge (PCK) for teaching Junior High School Science" to the University Extension Office. After its approval, the team had a negotiation with the Superintendent of the Department of Education of Valencia City Division for its implementation.

The teacher participants identified the subject that was difficult to teach and the challenging topics in that subject during the Needs Analysis. The team identified the enhancement activities, made a schedule, and implemented the activities. These activities constituted the training content and these had to answer the needs articulated by the participants. The training used demonstrations, film viewing, laboratory activities, simulations, and computer applications related to science teaching. Monitoring and evaluation followed up if what the teachers learned from the training was applied in the field. Finally, this research study determined the effectiveness of the extension training activities.

This study was the research component of this extension program. It analyzed the participants' scores obtained from the pretests and posttests of the different activities. It also analyzed the results of the Monitoring and Evaluation conducted. The different tests used were prepared by the team members. A Monitoring and Evaluation instrument was also crafted by the team to suit the objectives of the activity.

Descriptive statistics such as the mean, frequency counts and Paired Sample

T-test were employed to describe trends and differences in raw scores.

RESULTS AND DISCUSSION

Needs Assessment

A Needs Assessment was conducted before the set of activities in the training started. This Needs Assessment was based on the K-12 Curriculum Guide of the Department of Education. Table 1 shows the result of the Needs Assessment.

Table 1

Needs Assessment Results in PCK Science Extension Study

Part A – FIELD	Mean
Physics	4.83
Chemistry	4.15
Earth Science	3.67
Biology	2.35
Part B. CONTENT	
Use of Computer Applications in Science Teaching	4.56
Light	4.53
Electricity	4.50
Electricity and magnetism	4.48
Motion in Two Dimensions	4.45
Sound	4.44
Laws of Motion	4.24
Electromagnetic Spectrum	4.03
Work Power and Energy	3.78
Heat	3.71
Waves	3.47
Motion in One Dimension	3.21

The participants identified Physics as the most difficult Science subject to teach with a mean rating of 4.84. This is followed by Chemistry (4.15), Earth Science (3.67), and Biology (2.35). Biology is the least difficult science to teach.

In terms of the content, the topic on Light was considered by the teachers as the most difficult topic to teach in Physics. This was followed by Electricity, Electricity and Magnetism, Motion in Two Dimensions, and sound in descending order. On top of these difficult topics in Physics, the teachers chose the topic on

Use of Computer Applications as what they most needed to be enhanced with.

Number of Participants

A maximum of 16 and a mean of 13 participants attended the PCK Science training. Table 2 shows the dates of training, the topics taken up, and the number of participants in each session.

Table 2

Number of Training and Attendance of Teacher Participants

No.	Date of training	Topic	Number of participants
	May 16, 2018	Newton's Laws	15
	May 17, 2018 - AM	Projectile Motion	16
	May 17, 2018 - PM	Sound	15
	May 18, 2018	Optics	10
	May 19, 2018	Electricity	12
	June 30, 2018	Use of Computer Applications in Teaching	14
	July 7, 2018	Use of Computer Applications in Teaching	11
		Mean Attendance	13

The content knowledge mastery of the teachers was measured by the significance of the difference in the pre-test and post-test scores using Paired Sample T-test. Table 3 shows their accumulated scores.

Table 3

Pretest-Post test Scores of Participants

Teacher Participant	Accumulated Score	
	Pre-test	Post-test
	60	60
1.A	26	39
2.B	11	25
3.C	24	46
4.D	35	49
5.E	44	53
6.F	33	51
7.G	18	37

Table 3 continued.

Teacher Participant	Accumulated Score	
	Pre-test	Post-test
8.H	37	54
9.I	22	33
10. J	32	50
11. K	11	19
12. L	40	55
13. M	26	35
14. N	25	38
15. O	40	49
16. N	9	13
17. P	8	13
Mean Score	**25.94**	**38.53**
N	17	17
t	-9.397	
df	16	
Sig. (2-tailed)	.000	

Generally, each participant showed an increase in raw score after the training. There is a significant difference, using paired sample t-test, between the pre-test and post-test scores of the participants. These suggest that the content knowledge of the teachers improved after the training sessions. Therefore, the training sessions conducted did a great job of enhancing the participants' content knowledge mastery in the difficult topics.

However, when total scores were transmuted or converted into percentages, the mean percentage score of the pre-test is 54.34, that of the post-test is 79.82 as shown in Table 4.

Table 4

One-Sample Statistics comparing the mean values to 75

	N	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
PRE-TEST	17	54.34	14.44	3.50	-5.901	16	.000
POST-TEST	17	79.82	9.69	2.35	2.053	16	.057

When compared to the Dep Ed mastery level of 75, the pre-test mean score is significantly below the mastery level required by DepEd. Their post-test mean score of 79.82, though higher in value, is not significantly different from 75. The post-test mean score is just equivalent to the mastery level of 75 or barely passing. This implies that the training they had undergone was not enough in effecting high content mastery of the subject matter.

Pedagogy and Classroom Interaction

A rubric was used to evaluate teachers' applications of the concepts and skills. It was used by the evaluators during the monitoring visits. The content knowledge in teaching Science was measured by two verifiable indicators: content mastery and presentation. They obtained a low rating in these indicators. This is consonant to the result of the t-test for the post-test. The transmuted post-test in content knowledge mastery was just equivalent to 75. It implies that more training sessions may be conducted to achieve the second objective.

Table 5 below shows the results of the monitoring and evaluation based on the team prepared rubrics.

Table 5

Evaluation results of the teacher participants in PCK Science during the monitoring

Objectives	Verifiable indicators	Criteria	Mean Rating
1. empowered with important pedagogical content knowledge in the teaching	Content mastery	Substantive use of concept information: complete dimensions, accurate information, connections, and inferences are made, use of varied sources (4) Explanations of concepts indicate how the dimensions interact with each other; draw conclusions, make connections and inferences, accurate information, depends only on textbook. (3) Explanations of concepts aren't quite as complete, draw some conclusions and make some inferences but miss obvious ones, Information is mostly accurate with few minor errors, depends only on textbook. (2) Incomplete concept explanations with little or no indication of interaction among dimensions; Information is unreliable and/or inaccurate, present others' information without analysis (1)	2.40
	Presentation	Teacher is articulate and presentation is very clear (explains ideas, introduction and conclusion clearly, obvious transitions, doesn't use jargon, responds well to questions, speaks in sentences, clear enunciation, well paced, maintains eye contact, fits time requirement) (4) Presentation is comprehensible, with clear introduction, transitions, and conclusion; uses sentences, enunciates well, fluent, maintains an effective pace and eye contact but with some mannerisms, and doesn't run over allotted time. (3) Presentation is comprehensible and clear for the most part, but missing 1 or 2 important elements (2) Presentation lacks coherence and is not clear (1)	2.36

Table 5 continued.

Objectives	Verifiable indicators	Criteria	Mean Rating
2. acquired innovative approaches and strategies to enhance the teaching and learning processes in the classroom	Use of strategy	Very skillful, shows intense interest and ease in implementing a unique strategy that blends with the subject matter (4) Skillful, shows interest and ease in implementing a strategy that blends with the subject matter (3) Less skillful, shows mild interest in implementing any strategy (2) No strategy is used (1)	2.8
3. demonstrated fulfilling and lively classroom interactions.	Students' behavior	Students **almost never** display disruptive behavior during class. (4) Students **rarely** display disruptive behavior during class. (3) Students **occasionally** display disruptive behavior during class. (2) Students **almost always** display disruptive behavior during class. (1)	3.6
	Students' engagement in class discussion or activity	**Most students** contribute to class by offering ideas and asking questions, students were free to do their academic tasks. (4) **More or less 50% of students** contribute to class by offering ideas or asking questions (3) **Less than 50% of students** contribute to class by offering ideas or asking questions, students were free to do their academic tasks. (2) **Very few students** contribute to class by offering ideas or asking questions but students were free to do their academic tasks. (1)	3.51
4. Students' performance	Students' achievement	More than 50% of the students get scores of 75% and above (4) 50% of the students get scores of 75% and above (3) Less than 50% of the students get scores of 75% and above (2) No student gets a score of 75% (1)	2.7
Over all Mean rating			2.89

The teachers obtained a satisfactory rating for the third objective. The overall assessment obtained by the teacher participants in the applications of the pedagogies taught was 2.89, a satisfactory rating. They acquired and applied innovative approaches and strategies that enhanced the teaching and learning processes in the classroom. They used computer applications to enhance the learning of the students. They obtained a Very Satisfactory rating on the fourth objective.

The teachers demonstrated a fulfilling and lively classroom interaction. Students rarely display disruptive behavior during class. The performance of the teachers was rated 2.7 or satisfactory. More than 50% of the students got scores of 75 and higher.

CONCLUSIONS

Based on the results obtained, these were the conclusions given: Participating teachers identified the teaching of Physics very difficult, especially on the concepts of Optics, two-dimensional motions (i.e. projectile motion), electricity, sound, Newton's Laws of Motion, and Electricity and Magnetism. The content knowledge mastery of the teachers in the Science of Physics improved. It was below mastery, before the training, to a mastery level of 75, based on DepEd standards, after the training. The teachers acquired relevant pedagogical content knowledge in the teaching of Physics as a Science. After the training, they used computer apps in class, applied innovative approaches and strategies that enhanced the teaching and learning processes in the classroom. These were not observed before the training. Teachers have very satisfactorily demonstrated a fulfilling and lively classroom interactions. Students were busy talking about their lessons and in comparing results between groups. More than half of their students got scores of 75 and above.

RECOMMENDATIONS

Here are the relevant recommendations handed down by the team of the study based on the findings and conclusions of the study. Concepts need to be thoroughly understood first before appropriate blending of strategies with content shall happen. So extensionists and teacher participants may have to dig deeper behind why a topic is difficult to teach. Is it the lack of content knowledge mastery or the lack of pedagogy that causes the difficulty? Once determined, training may be provided. More rigid enhancement activities may be given for a more desirable content mastery level and to make the learning of a subject matter more interesting. Teachers may have more strategy exposure to acquire more knowledge and to be able to have the confidence to perform them by themselves. More training, especially with computer apps, may be provided to aid teachers in facilitating an attractive, interesting teaching-learning process in the classrooms.

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