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Navigating the Intersection: A Phenomenological Exploration of Physical Science Teachers Teaching Biology

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Abstract. This paper presents research on the lived experiences of physical science teachers teaching biology in junior high school. Previous research in teaching science in spiral progression approach identifies teachers' challenges and how they are overcoming them. This study adopted a phenomenological research design to provide a broader and in-depth insight into the specialized knowledge and understanding that physical science teachers possess about how to effectively teach biology to students. The findings informed that the orientation of the participants is practically didactic. Moreover, the overall PCK of the physical science teachers in teaching biology was adaptive or able to adjust to comply with the required learning competencies of teaching biology.

Keywords: Pedagogical-Content Knowledge; Spiral Progression; Biology Teachers; Physical Science Teachers; Didactic; Orientation to Science

1. Introduction

In the current science curriculum design in the Philippines, science teachers are teaching subject-specific domains in a spiral progression approach under the K-12 curriculum. These domains include Physics, Chemistry, Biology, and Earth Science.

Looking at the essential learning competencies, topics in grade 7 science immediately start its quarter on classifying substances, distinguishing substances from mixtures, and properties of solutions. It continues its 2nd quarter with parts and functions of the compound microscope, different levels of biological organization, the difference between animal and plant cells, reproduction, and organism's interaction to survive. The 3rd quarter is focused on Physics topics, including motion in one dimension, waves as carriers of energy, the characteristics of light, heat transfer, and the different charging processes. Lastly, the fourth quarter topics include the relation of the geographical location of the Philippines to its environment, different phenomena

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that occur in the atmosphere, relationship of the seasons and the position of the Sun in the sky, and occurrence of eclipses.

The essential learning competencies in grade 8 science need to deliver for the 1st quarter are the topics of laws of motion, work-force-energy, propagation of sound, properties of light, heat and temperature, and electric circuitry. It continues its 2nd quarter to the topics of faults and earthquakes, formation of typhoons, and characteristic of comets, meteors and asteroids. The 3rd quarter is focused on particle nature of matter, atomic structure and periodic table of elements. Lastly, the 4th quarter topics include systems of the human body, diseases resulting from nutrient deficiency, cell division, concept of species and flow of energy in the ecosystem.

For grade 9 science, the essential topics needed to deliver for the 1st quarter are the topics of different structures of the circulatory and respiratory systems and the prevention, detection, and treatment of related diseases, genetic information and patterns of inheritance, species extinction, photosynthesis and respiration. It continues its 2nd quarter with the topics of atomic models, types of compounds, organic compounds, and composition percentages. The 3rd quarter is focused on volcanoes, climate change, and constellations. Lastly, the 4th quarter topics include projectile motion, impulse and momentum, conservation of linear momentum, conservation of mechanical energy, the relationship among heat, work, and efficiency, generation, transmission, and distribution of electrical energy from power plants.

For grade 10 science, the essential topics that need to be delivered for the 1st quarter are the relationship among the locations of volcanoes, earthquake epicenters, and mountain ranges. It continues its 2nd quarter with the topics of the electromagnetic spectrum, images formed by the different types of mirrors and lenses, and electric motors and generators. The 3rd quarter is focused on nervous and endocrine systems, homeostasis, DNA, evolution, and species diversity. Lastly, the 4th quarter topics include gas laws, biomolecules, and chemical reactions.

Science teachers execute a combination of knowledge and pedagogy that determines the success of the transfer of learning to their students. Such decisions are largely influenced by their Pedagogical-Content Knowledge (PCK). Over 25 years ago, Shulman introduced the concept of PCK. He described it as

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the knowledge teachers use to transform subject matter for student learning, considering possible misconceptions and learning difficulties (Berry, Depaepe & Van Driel, 2016). Gudmundsdottir (1987) highlighted that PCK distinguishes teachers from scientists. While teachers may have similar subject matter knowledge, their organization and utilization differ. Several studies have used PCK as a theoretical lens to describe the framework of science teachers in the transfer of learning in the field. The study of Balmaña and Ligsanan (2023) is one of the studies that utilized PCK as a theoretical lens. They document the best practices in teaching science in kindergarten schools to create a model of the teaching-learning process that develops scientific explanations from the students. Through a case study research design, the experiences of two kindergarten teachers were analyzed using the lenses of Pedagogical Content Knowledge and Elements of Scientific Explanation.

Magnusson et al. (1999) identified nine different science teaching orientations. These are process (emphasizes understanding scientific processes and methods), academic rigor (focuses on maintaining high standards and intellectual challenge), didactic (involves direct teacher-led instruction), conceptual change (aims to shift students' existing misconceptions), activity-driven (Centers on hands-on, experiential learning), discovery (Encourages student exploration and self-discovery without specific direction or guidance), project-based science (Teacher and student activity centers around a "driving" question and through investigation, students develop a series of artifacts or products), inquiry (teacher promotes student questioning, provide resources and support as needed but the students have the freedom to direct their own learning journey and seek answers independently), and guided inquiry (provides more structure and direction from the teacher. The instructor guides students through the inquiry process by posing specific questions, suggesting research methods, and helping interpret findings).

Together with orientation to science teaching Magnusson et. al (1999) identified four more facets of PCK of science teachers. These are the knowledge of science curricula, knowledge of student understanding of science, knowledge of instructional strategies, and knowledge of assessment of scientific literacy.

The knowledge of science curricula includes the knowledge of teachers in specific science curricula. This facet also consists of the teacher's knowledge in science goals and objectives.

The knowledge of students' understanding of science includes the teacher's knowledge of the learning requirements. This facet also consists of the teacher's knowledge in locating the students' areas of difficulty in the lesson.

The knowledge of instructional strategies reflects the teacher's knowledge to utilize science-specific strategies for any topic. This facet also includes the knowledge of a teacher to use representations to deliver abstract concepts and create activities to facilitate the transfer of learning.

The knowledge of assessment of scientific literacy shows the knowledge of the teacher on selecting appropriate methods for assessing science learning. This facet also includes interpreting assessment results.

The transition of the topics covering different topic-specific contents from 4 different domains (Physics, Chemistry, Biology, and Earth Science) requires holistic training and preparation to prepare the teachers to conform to pedagogical content requirements.

Moreover, teachers' knowledge informs their practices and directs their actions in the classroom (Barnett & Hudson, 2001). Placing them in a field they are not accustomed to will at least give them the feeling of uncertainty which can affect their performance in the complex delivery of science lessons where relationships between teachers' knowledge structures, classroom practice, and student achievement exist (Baxter & Lederman, 1999).

Due to the aforementioned issues, the intersection between physical science and biology teaching represents a critical juncture that must be explored to demystify critical elements that can enlighten education experts for the possible crafting of best practices or reveal further room for improvements.

This study aims to explore the lived experiences of physical science teachers as they engage in teaching biology in junior high school. Through phenomenological inquiry, we seek to uncover the essence of their pedagogical content knowledge related to biology instruction.

2. Methodology

2.1. Research Design

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The research design used in this study was descriptive phenomenology, as developed by Dahlberg et al. (2008). Descriptive phenomenology is a qualitative approach that aims to describe the essence or structure of a phenomenon as it is experienced by the participants, without interpretation or explanation. Descriptive phenomenology is suitable for the purpose of this study, which is to explore the lived experience of physical science teachers teaching biology and to understand the meaning and significance of their experience for their professional development and practice.

2.2. Respondents

The population of the study involved science teachers in the junior high school level of public secondary schools in the province of Bataan. The screening for qualified participants of the study was based on the following criteria: (i) with full-time or permanent status, (ii) experienced in teaching biology for at least 4 years and (iii) graduated with a science education degree by specialization in Physical Science or Physics. Three science teachers qualified to be the respondents of the study.

2.3 Data Analysis

The data analysis method used in this study was qualitative thematic analysis based on descriptive phenomenology, as proposed by Dahlberg et al. (2008). This method is suitable for the purpose of this study, which is to describe the essence or structure of the phenomenon of interest, as it is experienced by the participants, without interpretation or explanation.

The method consists of six steps, which are:

i. Reading the whole interview transcripts several times to get a sense of the whole.
ii. Identifying and dividing the text into smaller units of meaning that capture the essential aspects of the phenomenon and the participants' experiences.
iii. Abstracting and labelling the meaning units.
iv. Comparing and contrasting the meaning units and labels. This step involves examining the similarities and differences among the meaning units and labels across the data set and identifying patterns and variations in the data.
v. Organizing the labels into clusters and themes.
vi. Describing the structure of the phenomenon. This step involves synthesizing and integrating the themes into a coherent and comprehensive description of

the essence or structure of the phenomenon, as it is experienced by the participants.

The data analysis process was guided by the principles and concepts of descriptive phenomenology, which include: 1) bracketing one's own preconceptions and assumptions about the phenomenon, 2) focusing on the lived experiences of the participants as they describe them, 3) using a reflective and open attitude to the data, 4) avoiding interpretation or explanation of the data, and 5) seeking the essence or structure of the phenomenon (Dahlberg et al., 2008). The data analysis process was also supported by peer debriefing and member checking.

3. Results and Discussion

Cross-view of related data from the shared experience of physical science teachers teaching biology resulted in the development of two models that portray a deeper, more specific understanding of their multidimensional nature and experience. The framework of orientation to science teaching of Physical Science Teachers teaching Biology (See Figure 1) and the complete PCK Framework of Physical Science Teachers teaching Biology (See Figure 2).

3.1 Orientation to Science Teaching

The science teachers' positive orientation to science teaching can be described as "practically didactic". This term captures the essence of a teacher who applies practical experiments and activities in the classroom while maintaining a more traditional, lecture-based approach to teaching, without actively involving students in research.

In terms of developing the students' science process skills, the science teachers exposed students to guided laboratory experiments. The components of the laboratory experiments comprised the essential elements of Science: A Process Approach (SAPA).

The teachers challenge the students to promote academic rigor by asking higher-order thinking skills (HOTS) questions during discussions and post-laboratory reports or presentations of the students. Teachers also reported each experiment to promote a high level of science learning.

Didactic lectures are a way for teachers to manage concept formation and diagnosing student misconceptions by means of probing questions. Through lectures one teacher mentioned this as a way to relate the covered lesson to future lessons in the next grade level of the students.

To promote conceptual change, all science teachers utilized the "presentation-revelation-verification" process. In this process teacher first allow the student to present their naïve conceptions through reporting of laboratory reports or answering questions during lectures. Then, the teachers reveal the correct concept supported by related evidence. Finally, the teachers provide formative assessment or experiment to verify if the students already corrected or changed their misconceptions. In terms of verification stage, one of the science teachers reflected the uncertainty in biology concepts. She revealed consulting colleagues to verify the detail of the concept.

The science teachers showed in their answers the strong quality of providing hands-on activity to their students. Some of the activities presented by the science teachers are creating model and mimicking forensic investigations.

Exploration or discovery was also promoted by the teachers by providing triggering activity only to their students. They reported providing assignments for reporting of application of discussed concepts to real-life situations, providing supplement videos and reading materials related to the past lessons, and providing computer applications and websites for exploration of additional topics in biology.

Low involvement in project-based science was reflected by the teachers. Only one science teacher reported successful delivery of a driving question that drives student led activities within a topic of study. This happened due to the second faculty load of the teacher which is research where the students can present preliminary data of their approved research study to the biology class.

Inquiry requires investigation that is student-directed. The science teachers successfully provide partial assistance to facilitate this process which is more concentrated in answering student questions through open forum and referring the students to experts for consultation. Only one teacher reported successful student-directed investigation which is the one connected to teaching research and coaching science investigatory project.

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Low involvement in guided inquiry was presented by the science teachers. Only one science teacher reported successful delivery of complete guided inquiry since the teacher was also teaching research and active in research advising of investigatory project.

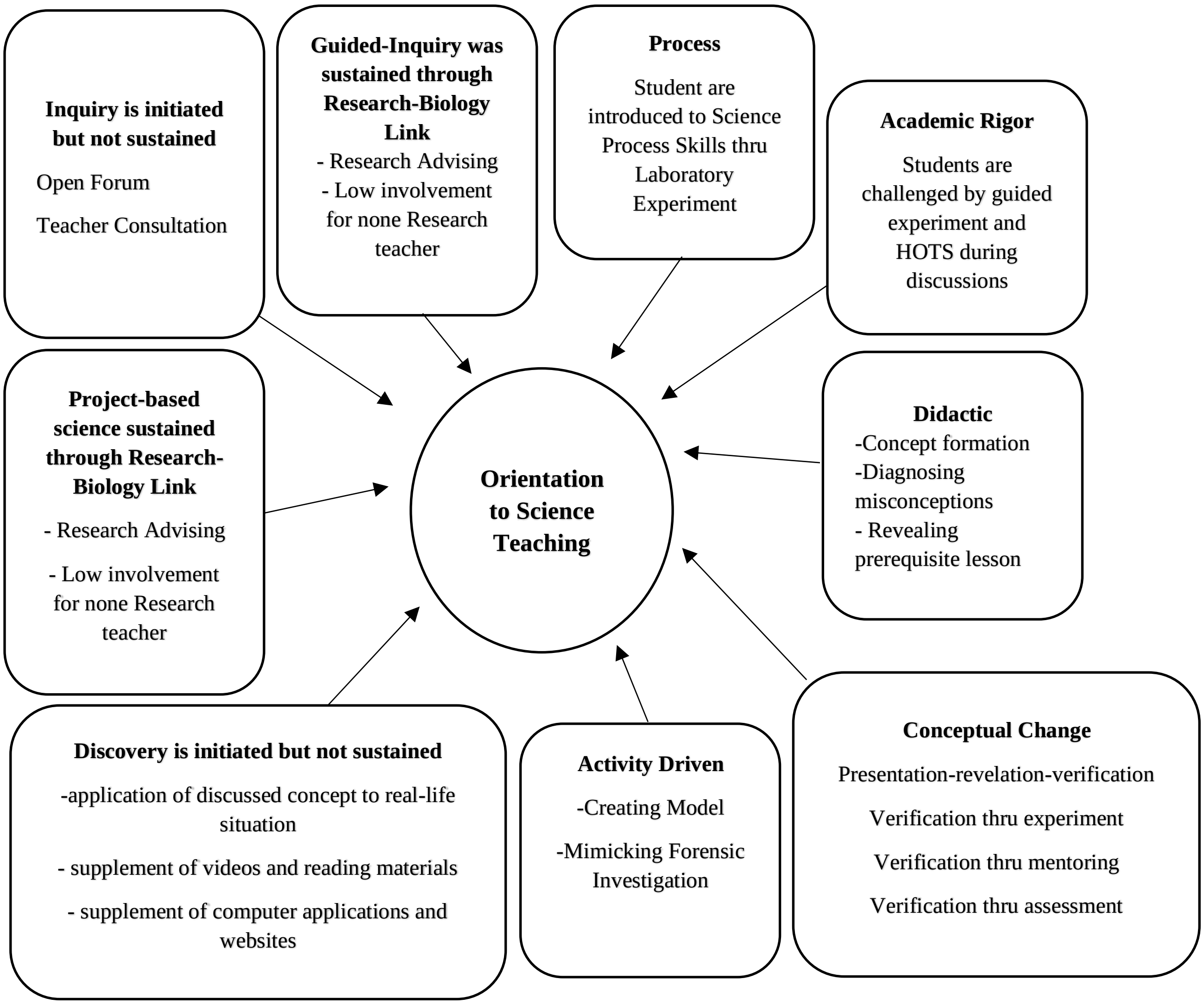

Figure 1 Framework of orientation to science teaching of Physical Science Teachers teaching Biology.

3.2 PCK of Physical Science Teachers Teaching Biology

A more comprehensive picture of the entire experience of Physical Science Teachers teaching Biology was then developed comprising their orientation to science teaching, knowledge of science curriculum, knowledge of student understanding in science, knowledge of instructional strategies, and knowledge of assessment of scientific literacy, all categorized within six primary themes. These six fundamental elements/themes provide an overall, foundational understanding of the nature of their teaching experience in Biology.

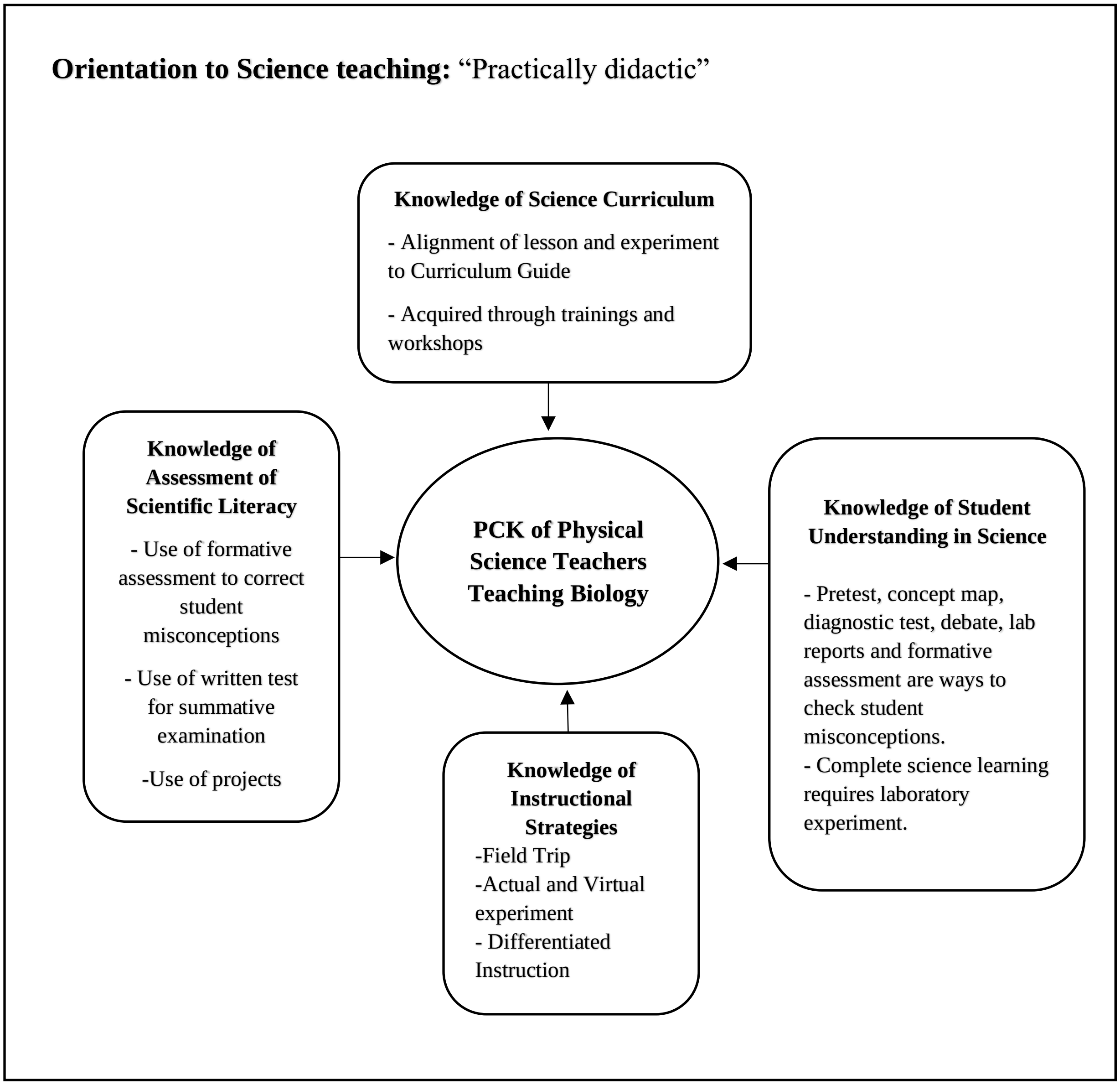

Figure 2 PCK Framework of Physical Science Teachers in Teaching Biology.

The orientation to science teaching of the science teachers provides an overarching theme that encompasses the other 4 facets of their pedagogical content knowledge. After examining the data patterns from nine pre-conceived

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themes of different orientations to science teaching, it can be deduced that the participants have a positive orientation and are oriented to be practically didactic.

The knowledge of physical science teachers in science curricula specifically in Biology was anchored in the curriculum guide of DepEd Philippines. They religiously aligned the objectives of their lesson on the proposed learning competencies assigned for the grade level they were handling. Although they have established science goals and objectives since their baccalaureate degree, these were gradually enhanced through seminars and workshops attended by teachers.

Although they are physical science teachers teaching in the field of Biology, they are aware that complete science learning requires laboratory experiments. To locate students' areas of difficulty in the lesson, teachers utilized various avenues which included pretest, concept mapping, debate, and presentation of laboratory reports, formative assessments, and diagnostic tests.

The pool of instructional strategies revealed by the physical science teachers in teaching biology includes field trips, experiments, and differentiated instruction. It was emphasized that experiments in biology are classified by teachers as actual and virtual. Virtual laboratories are utilized by teachers to deliver laboratory using simulations, especially in situations that require distance learning and lack of science equipment.

The knowledge of assessment of scientific literacy of the science teachers showcases their use of formative assessment to correct student misconceptions and the use of written summative examination to reveal learning gained by the students from the covered lessons. The use of projects also emerged as an alternative assessment if the competency requires application of learned concepts.

4 Conclusions

The intersection of physical science topics and life science topics in the spiral progression approach in the K to 12 curriculum has been a heated issue since its birth and even at the height of its implementation. Even in the current era, it reflects the public desire to understand if a physical science teacher can competently teach Biology in the field. The PCK Model and Orientation to Science Teaching Model of Physical Science Teachers in Teaching Biology provides an educational tool to work with Physical Science teachers prior to and around the time of teaching Biology.

The Orientation to Science Teaching Model revealed the weakness and strength of physical science teachers' mindset, beliefs, and approach when teaching biology. The model can be used by experts who craft and lead professional training programs. It can be deemed from the model that priority must be aligned in trainings that will enhance the teachers' immersion to discovery approach, project-based learning, inquiry and guided inquiry. These approaches empower students to actively construct knowledge, think critically, and engage with real-world challenges.

Aside from the orientation of the participants being practically didactic, the overall PCK of the physical science teachers in teaching biology was adaptive. The teachers are able to adjust to comply with the required learning competencies of teaching biology.

As a qualitative study, the research is limited in its ability to be generalized. This research and the two theoretical models were based on the qualitative investigation of three participants in a particular context. The findings are enriching to the field of science education research. Broader application would require testing of the models and replication of the research in various contexts.

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