

Towards A Capacity-Building Framework for Science Laboratory Teaching: A Qualitative Study of Secondary School Teachers

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Abstract

The instruction of science laboratory is essential to building up the scientific knowledge and the skills of students, but the implementation of the laboratory instruction is a complicated set of abilities which are not always thoroughly discussed on the side of teachers. The perceived competencies, challenges, and professional needs of junior high school science laboratory teachers in the public schools were the subject of this qualitative descriptive research. Focus group discussions and semi-structured interviews were used to collect data by interviewing 15 purposely selected science laboratory teachers and analyzing data with the help of thematic analysis. The results showed five key themes, which include Scientific Knowledge and Laboratory

Skills, Pedagogical knowledge and classroom management, the Teacher as a Constant Learner, Technological Knowledge and Evaluative Ability. The findings outline that competence in science laboratory teaching is a multifaceted experienced that is influenced by the teachers personal capacity as well as situational constraints. The study emphasizes the importance of long-term, context-specific capacity-building programs that promote scientific, pedagogical, technological, and evaluative skills of the teachers. These results are added to the qualitative science teacher competence literature and offer practical implications to the teacher development and education leadership.

Keywords: *science laboratory teaching, teacher competence, professional development, qualitative study, secondary school*

INTRODUCTION

Laboratory teaching is an important part of an educational process of studying sciences as it provides learners a chance to participate in scientific investigation, through solving problems; and create meaningful learning by applying hands-on experience through actual experimentation. To make laboratory experiences more meaningful, effective teaching goes beyond procedural demonstrations as it serves the purpose of teachers to combine scientific knowledge with pedagogical skills, classroom management and reflective practice that will provide the learners more learning opportunities, as this are the requirements of teaching methodology for improving scientific literacy (Supriyatman et al., 2024).



In secondary schools, especially, in junior high school, the competence of a science laboratory teacher plays a major role in applying scientific concepts and mastery of the skills most especially when it is well planned and guided by a qualified and competent science teacher. In most public schools setting, teachers are expected to fulfill numerous roles that will encompass pedagogical skills and understanding that will best describe “competency” in science laboratory teaching. These competencies are significant and at the same time a challenging task for most science teachers handling 21st century learners, including the pressure of expectations of having a strong and efficient professional attribute in operating our educational system (Nipales, 2019).

In spite of the acknowledged significance of laboratory-based instruction, science teachers usually face consistent challenges in effective implementation of laboratory activities. The lack of modernization in laboratory equipment due to financial constraints, unpreparedness of the teachers, poor delivery in facilitating the lesson and lack of management and planning skills will have a consequence and bearing on the students learning process that might impede the learners understanding of the scientific concept (Dimaranan & Chua, 2020).

In our modern world where technology is at its prime, it is changing how science education are being delivered in classrooms. Science education are becoming more technological where classroom apparatuses are upgraded and hands-on experiences are trying to catch up to meet the demands of the curriculum. Teachers, therefore, must learn to acquire and design adaptable routines appropriate for science teaching and learning so that individual learner will have a sufficient opportunity to make adjustment and work freely and independently with self-reliance whether the task is done collaboratively or independently (Tomlinson & Sousa, 2020).

In the Philippine context of the public school system, science teachers are working with varying institutional and environmental challenges. These situational variables highlight the necessity of a detailed qualitative study of science laboratory instruction, based on teacher perceptions and experience of teaching in the real laboratory setting. Hence, this is necessary not just to describe current practice, but also to inform the design of responsive and sustainable professional development programs because it would help schools and administrators to understand the views of teachers.

Numerous research on the topic of teacher competence in science education has been based on the quantitative perspective; including surveys, performance measures, and standardized measurement instruments. Although these methods offer a lot of important insights into the overall competency levels, they do not always reflect the subtle experiences, beliefs, and contextual realities that explores how teachers define competence, express their professional needs, and describe conditions that hinder them in delivering effective laboratory instruction.

This qualitative study will enable the recognition of patterns, themes, and meanings in the story of the science laboratory teachers to give a deeper insight into competence as an evolving and multidimensional phenomenon. This kind of information would be especially useful when creating capacity-building interventions that would reinforce laboratory instruction in secondary school.

The aim of this qualitative study was to determine the perceived competencies, challenges, and professional needs of science laboratory teachers in the junior high schools in selected public schools of Cavite. In particular, the research aimed to explain the conceptualization of competence in laboratory



teaching by science laboratory teachers, and how their experiences could be used for a capacity-building framework that can guide the science education.

The results of this study contribute to the existing qualitative research on the competence of science teachers by anticipating the opinions of laboratory educators themselves. The study can offer empirical evidence that can be used in developing teacher education, in-service, and school based professional development programs, by revealing the key themes with regard to scientific knowledge, pedagogical skills, professional attitudes, technological competence, and evaluative practices.

The evidence-based information gathered from this study will provide educational leaders and policymakers relevant capacity-building programs to meet the real needs of the science laboratory teachers. To researchers, the research study poses the importance of qualitative methods in the investigation of teacher competence as a phenomenon that is complex and contextual. Finally, the study demonstrates the need to encourage science laboratory teachers to design learning experiences that are meaningful and inquired-driven experiences to the students.

METHODS

Qualitative descriptive research design was employed to investigate competencies, challenges and professional needs of 15 science laboratory teachers in junior high school in selected public schools in the Division of Cavite. The qualitative descriptive method was used to provide an opportunity to narrate the experiences and views of the participants in a rich and natural way, using their own words, without applying theoretical interpretations to their experiences and views. The design helped the researcher to get contextualized data on the practices of teaching and competence of teachers in real educational settings.

A Focus Group Discussion (FGD) questionnaire used to obtain information on science laboratory teachers on strategies and activities that teachers utilized to meet their needs in conducting laboratory activities.

A letter of request to conduct the study was sought to the different Division Superintendent of Cavite for endorsement to the school principal to conduct the study. Focus group discussions (FGDs) and semi-structured interviews were used to collect the data through a series of interactions with the involved science laboratory teachers. All observations were made during the FGD while challenging the interpretations that may arise by asking more specific questions as it could be useful to explore the in-depth experiences of the participants. These was audio recorded with the consent of the participants so that the responses could be recorded accurately and later transcribed verbatim to be analyzed.

The data collected were transcribed and coded after which categories and themes were recognized based on patterns that have emerged from the information. Through thematic analysis all information gathered uncovered emerging patterns that exemplified the experiences and views of the teachers.

RESULTS

The following section gives the qualitative results of this study that were based on the discussions in focus group discussion with science laboratory teachers of junior high schools. The review indicated that



there are five significant themes that characterize the perceptions of competence, challenges, and professional demands by the teachers in undertaking laboratory instruction. These themes represent the ideas of how teachers perceive effective teaching in the laboratory in the framework of the public secondary schools and the realities of the scenario in which they teach.

Theme 1: Laboratory Skills and Scientific Knowledge as the Prerequisites of Competence

The participants of this study always stressed that effective science laboratory teacher requires a solid knowledge in sciences and laboratory skills. Teachers emphasized that in order to be a competent teacher, they must be first knowledgeable in the subject matter to instruct students throughout the experiment; clear if there are misconceptions, and react to unforeseen findings. Therefore, one must possess the skill of demonstrating the correct scientific concepts, managing the laboratory equipment correctly, and securing proper experimentations since lack of mastery in laboratory skills was seen to be one of the limitations to quality instruction especially when experiments failed to go as scheduled.

The respondents also mentioned that laboratory competence is not only theoretical but also practical in terms of familiarity with equipment, and chemicals as well as safety measures. The teachers addressed that they could not always carry out laboratory work with confidence due to the lack of opportunities that could give them practical training.

Theme 2: Pedagogical Knowledge and Classroom Management in the Laboratory Environment.

In addition to scientific knowledge, pedagogical knowledge and classroom management were also found to be one of the important aspects of laboratory teaching competence. The participants referred to the laboratory as a place that is chaotic at times when one does not possess the management skills. Efficient teaching involves proper planning, communication, and behavioral management of students in order to meet proper dynamics and harmonious working environment.

Educators stressed the necessity to transform complicated scientific concepts and application into comprehensible instructions and scaffold the laboratory work based on the abilities of students making laboratory work more understandable and meaningful. Distribution of time, grouping and discipline were considered as key skills and especially when dealing with large classes.

Some of the challenges mentioned by the participants were associated with balancing the inquiry-based learning with classroom control. Although teachers admitted that student-centered laboratory activities are valuable, they admitted that it is challenging to control order and make sure that students are safe when they do hands-on experiments.

Theme 3: The Teacher as a Constant Learner

One of the most noticeable themes that were revealed in the data is that of a teacher as a constant learner. Professional development was perceived as a continuous task by the participants, particularly with regards to curriculum modifications, methods of teaching and scientific development.



The teachers said they desired further professional growth especially in training on laboratory procedures, innovative teaching methodologies and curriculum development. Several of them reported that they were unable to develop professionally due to the lack of access to seminars and workshops.

This theme is applicable because teachers understand that competence is not fixed and thus is developed over time through experience, reflection and learning. Respondents noted that to ensure effective laboratory in the long term, the support and learning opportunities are essential.

Theme 4: Technological Knowledge as a New Demand in Laboratory Training.

The technological knowledge as a component of laboratory teaching competence was determined by teachers as an ever-growing phenomenon. They said that the use of technology including digital simulations, multimedia presentation, and online materials was found to be helpful in improving the scientific knowledge of learners especially in cases where physical laboratory materials were scarce and laboratory activities were limited most especially during the pandemic brought by COVID19, where most activities were diverted to online sources and delivery.

Nevertheless, issues of poor access to technological devices, lack of training in their use, as well as the degree of digital literacy, were also noted among teachers. Part of the participants stated that technology might be an addition to the laboratory teachings, but they needed further assistance in order to successfully implement the technology in their lessons.

This theme establishes the increasing demand that science laboratory teachers should adjust to learning environments that are technologically enriched, even within the constraints of structural and resource requirements.

Theme 5: Evaluative Ability and Laboratory Evaluation.

The last theme is concerned with the capacity of teachers to evaluate students learning in and out of the laboratory activities. Participants insisted on matching the assessment plans with goals of laboratories and achievement of students. As teachers explained, it was difficult to measure the process and products of a laboratory work, such as it was not easy to evaluate students reasoning in the scientific field, their teamwork, and their ability to perform the procedures correctly. The participants stated that they needed more specific assessment tools and guidelines, which could enable them to assess laboratory performance more with ease and impartiality.

This theme emphasized the complexities of laboratory assessment and the importance of evaluation that applicable to both cognitive and practical aspects of student learning.

DISCUSSION

The qualitative research examined the perceived competencies and professional challenge of junior high school science laboratory teachers. It has been found out that science laboratory teaching competence is a multidimensional and context-based construct, influenced by the scientific expertise of the teachers, their pedagogical, orientation of their career through professional learning, adaptability to technology and evaluative skills. The discussion interprets the result concerning the available theories and literature and outline their implications on the science education practice and professional development.

Laboratory Teaching and Scientific Knowledge Pedagogical Content Knowledge.

The orientation of the participants towards knowledge and skill in laboratory is in line with Pedagogical Content Knowledge (PCK) concept given by Shulman (1986), which emphasizes on the combination of the subject and pedagogical knowledge. As shown in the narratives of teachers, the ability to teach in a laboratory is based not only on the knowledge of scientific concepts but also on the knowledge of how to present these concepts in forms of experiments, demonstrations, and activities that involve inquiries.

The results indicate that the educators who have low confidence in laboratory work or scientific applications are limited in their capacity to enable meaningful laboratory experiences. This is in line with the findings of previous studies that show that low levels of content mastery lead to low quality of instruction and student involvement in science laboratories. But generally, regardless of having low confidence, teachers need to fulfill their duties and must be able to carry out their responsibilities by applying their pedagogical skills and competence that will accomplish the expected quality standards or norms (Yusnita et al., 2018). Therefore, the combination of knowledge, skill and instructional judgment is significant.

Pedagogical Knowledge and Classroom Management in the Laboratory Environment.

The complexity in applying the principles of pedagogical learning in real-life classrooms is reflected in the ways that teachers discuss classroom management issues in laboratory. Instruction in the laboratory is student-centered, and inquiry-based in nature; nonetheless, participants noted issues between promoting exploration and safety, order, and time efficiency.

Based on constructivist theory, a productive learning in the laboratory needs to have an environment where students build knowledge through experimentation and reflection. This theory must attain the so-called balance or "equilibrium" in a learning environment which has something to do on how an individual constructs its own knowledge through its physical activity (Amineh & Asl, 2015).

Reyes et al. (2014) points out that in terms of instruction, Constructivism must have the basic principles that a learner must experience by allowing the learner to make mistakes and process the "hands on" experience through experimentation on its own and operate process that will lead to conversion of reality.



This research indicates that educators should be provided with assistance in dealing with such settings without falling back to teacher-centered methodologies. This supports the study that pedagogical competence in laboratory instructions incorporates the capacity to balance inquiry and structure especially in big or resource constrained classes. Inquiry learning is one method that is found effective to the learners if they are guided properly by their teachers and its success also rely on the learners prior knowledge, the area, and their relationship (Riesen et al., 2019).

The Teacher as a Constant Learner

The teacher being a continuous learner is well correlated with the theory of adult learning (Knowles, 1980) that has focused on self-directed learning, relevance and experiential learning. The statement by participants about their wish to continue professional growth is an indication that they are aware of the fact that teacher competencies changes as a result of reflection, practice, and continuous learning opportunities should never cease.

The stories of teachers show disparity between the expectations of the institution and the available professional development support in reality. This observation replicates the literature which proposes the hypothesis that, during the formation of complex teaching competencies, one- time training processes are inadequate (Palines et al., 2021). Rather, there is need to have long term context-based capacity-building programs that address the professional development of teachers especially in laboratory-based teaching.

Technological Knowledge as a New Demand in Laboratory Training

Teachers considers technology as a helpful tool to laboratory teaching, particularly where physical facilities are in short supply. Nevertheless, the problems of access, training, and online confidence mean that the technological integration process is still not balanced.

It has been found that technological competence in laboratory instruction is not to be viewed as a single skill but rather as an inseparable part of pedagogical and content knowledge. Proper development as a professional should therefore not only take care of the utilization of tools but also the significant integration of technology.

Evaluative Ability and Assessment of Learning

The complexity of authentic assessment in science education is highlighted by the challenges that teachers have in the process of assessing laboratory learning. There are both cognitive and procedural learning outcomes in the laboratory activities, which is more difficult to assess compared to traditional written examinations.

The results substantiate the current studies that recommend assessment practices that can be used to measure process skills, collaboration, and scientific reasoning. The laid-out expression of the necessity of teachers to have clearer assessment tools indicates that evaluation competence is a highly vital but

unsupported aspect of laboratory teaching. Developing teacher evaluation expertise can be used to bring about more valuable assessment that is consistent with inquiry-based science teaching.

To present the implications of the study, it is important to note that the results revealed the necessity of specific professional development programs for science education that should be focused on the scientific knowledge, pedagogy, classroom management, technology integration, and assessment in the laboratory settings.

The implication of the findings to policy and school leadership, entails the sustainability of institutional support, adequate resources, and organized capacity-building systems to science laboratory teachers for additional professional development.

Subsequent researches can further develop the findings and results of this study by considering similar settings or use of longitudinal qualitative methods to further study teacher competencies as a contextual and lived experience.

Conclusion

This qualitative study gives realistic evidence on the conceptualizations of competence as developed by science laboratory teachers and their strategies of overcoming the issues of laboratory instruction. The study gains a better insight of laboratory teaching competence as a multifaceted experience that is dynamic by foregrounding the voices of teachers. The results are used as a qualitative base to create responsive structural frameworks of capacity-building to facilitate appropriate instructions in science laboratories.

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