Examining ICT and FoK integration in Rural Public Junior High Schools with the Philippines' New K-12 Curriculum: A Case Study

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Curriculum Studies)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

July 2020

The following individuals certify that they have read, and recommend to the Faculty of Graduate and Postdoctoral Studies for acceptance, the dissertation entitled:

Examining ICT and FoK integration in Rural Public Junior High Schools with the Philippines' New K-12 Curriculum: A Case Study

submitted by Gerald Gallego Tembrevilla in partial fulfillment of the requirements for

the degree of Doctor of Philosophy

in Curriculum Studies

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Abstract

This is a nested, descriptive, and interpretative case study on the use of information and communication technology (ICT) in science education in select rural public junior high schools in the Philippines. Using mixed methods, the study investigated key challenges faced by science teachers as they integrate ICT in their classes viewed through the lenses of technological, pedagogical, and content knowledge (TPACK) and funds of knowledge (FoK). In-depth quantitative and qualitative analyses were drawn on teachers' online questionnaires, one-on-one interviews, focus groups, fieldnotes, and observations and reflections on science video-creation workshops.

Three overarching findings emerged from the data analyses: TPACK as a foundational professional development enabler; FoK as a bridge to enhance teachers' TPACK; and the successful implementations of ICT-centred science curriculum and pedagogy as policy- and governance-dependent. These findings described the contained experiences of science teachers as enablers of innovative rural science teaching practices. The study documented how science teachers overcome functional fixedness of educational technology. This, in turn, allowed them to identify the affordances and constraints of such technology. In rural schools where the shortage of educational resources is a perennial problem, prevailing over a state of functional fixedness related to a technology's particular function and exploring different and more creative ways to use such technology was a highly welcome educational technology crossover. Moreover, this study recorded a positive expansion of science teachers' TPACK. The expansion was brought about not only by a change in any of the TPACK's components but by the use of technology along with students' FoK through science video-creation.

This study contributes to our understanding of teaching science with ICT and FoK in rural public high schools. Moreover, it underscores areas for consideration in developing countries with similar circumstances such as the Philippines regarding: (a) centering ICT investments on teachers and teaching; (b) clarifying ICT policies' terms of implementation, noting that different definitions lead to different policy investments and recommendations; (c) introducing science video-creation as a professional development program for teachers in rural public schools; and (d) recognizing rural public schools and their teachers as places and people of innovation and alternatives of pedagogical effectiveness.

Lay Summary

This study investigated the key challenges faced by select Filipino rural science teachers as they used technology in a new K-12 curriculum. Drawn from in-depth analyses of teachers' questionnaires, interviews, and video-creation workshops, the results indicated that science teachers struggle with limited educational technology to master science content and pedagogy. The struggle steered teachers to explore creative ways a technology can function. This study documented an expansion in science teachers' knowledge related to technology, pedagogy, and content through the use of technology and students' funds of knowledge in science video creation.

This investigation contributes to our understanding of teaching science with technology and local knowledge in rural areas. It underscores areas for consideration such as centering investments for teachers and teaching, and clarifying institutional policies to match teachers' professional development needs. It also recognizes public rural schools as places of innovation and alternatives of pedagogical effectiveness.

Preface

This dissertation is original and unpublished work by the author, Gerald G. Tembrevilla. The research was designed, carried out, and analyzed by Gerald G. Tembrevilla with full support from Drs. Marina Milner-Bolotin, Samson Nashon, and Patricia Duff.

This research obtained the approval of the UBC Behavioural Research Ethics Board (BREB) with UBC BREB Number: H18-02992.

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Acknowledgements

I would like to express my enduring and heartfelt appreciation to my supervisors Drs. Marina Milner-Bolotin and Samson Nashon together with Dr. Patricia Duff as a member of my committee. Thank you very much for a remarkable mentorship, guidance, and support. I will be eternally grateful to all of you.

This research would not have been possible without my research funders and collaborators:

UBC Graduate & Postdoctoral Studies Public Scholars Initiative

UBC International Tuition Award

UBC Faculty of Education Graduate Scholarship

UBC Department of Curriculum and Pedagogy Graduate Student Research Travel Award

UBC Mitacs-Canada Globalink Research Award

UBC Go Global Scholarship

UBC CTLT and the Institute for the Scholarship of Teaching and Learning

UBC Philippine Studies Series

UBC Joseph Katz Memorial Scholarship Endowed Award

Staff, Science Teachers, Department Heads, Principals, and Superintendents at the Department of Education, Division of Bago City, Negros Occidental & Region VI Office, Philippines

Prof. Kimberly Gomez, UCLA Department of Education and Information Studies

Prof. Dr. Andreas Vaterlaus, Dr. Guillaume Schiltz, and ETH Zurich Solid State Physics and Physics Education Group

Prof. Keith S Taber, University of Cambridge, Faculty of Education, Science Education Centre

Dedication

I dedicate this dissertation to my family, dear parents and siblings in the Philippines, friends, mentors, and former students in the Philippines, Japan, U.S.A, Switzerland, U.K., and Canada. Thank you very much for the motivation, inspiration, love, and care.

Chapter 1: Introduction to the Study

1.1 Introduction

The year 2008 was a monumental year for those who study demography, economics, education, etc. In this year, for the first time in the history of humankind, the number of rural settlers was overtaken by the number of urban dwellers (UN, 2018). Urbanization and migration have provided momentum for the increase in the global urban population, while the global rural population is projected to plateau in the next two decades (UN, 2018). Long before that historic event of 2008, the rural population had been cast aside as a "forgotten minority" in public and educational discourses. They were stereotyped as uneducated, marginalized, and inefficient (Shafft & Youngblood Jackson, 2010; Azano, 2015; Reagan et al., 2019). However, heightened economic, political, and cultural globalization (Drainville, 2004)—including increasing calls for equity, diversity, and inclusion across levels of education in recent years—has afforded a renewed interest in rural communities for research, policy, and practice. The proliferation of mass media, communication and information technology (ICT), and educational reforms as countries confront 21st century digital education and globalization are reshaping rural education with new opportunities and challenges.

Several international organizations (World Bank, 2017; OECD, 2018, 2019) are highlighting the vital role of teachers in globalization. Global competition, as seen in every country's policies, relies heavily on the use of ICT (Lubin, 2018). The desire to be economically competitive represents a persuasive argument for a country to justify huge investments in "educational improvement and the applications of ICT in schools" (Kozma, 2005, p. 118).

While Trucano (2016) highlights that the “potential and promise of ICT use in education is clear in many regards” (p. v), he also acknowledges that there are risks like “disruption of existing traditional teaching and learning practices, high costs, [and] increased burdens on teachers…” (p. v). In addition, Trucano (2016) noted that, in country-wide ICT initiatives in the case of developing countries, “support for teachers is often deemphasized in the early stages of ICT rollouts” (p. 4). Although teachers are highly regarded as the “cornerstone of educational development and…‘good schools require good teachers’” (Cheng et al., 2004, p. ix), there are growing concerns regarding teachers’ situations in developing countries. They have poor working conditions, low salaries, and inadequate training and access to quality professional development (PD) (UNESCO 2003; World Bank 2005, 2017; LeTendre & Wiseman, 2015). As developing countries are extensively expanding the roll-outs of ICT initiatives in education, there is a critical need for research-based data on teachers’ actual situations, such as their use of ICT in teaching and learning, the difficulties encountered by the teachers while using ICT, etc. These data are crucial to ascertain teachers’ PD needs and match institutional policies with the implementation of initiatives in education and ultimately the delivery of quality education to the learners.

The Philippines, with a population of more than 108 million—nearly three times bigger than Canada (Population, 2019)—is one of the developing nations rolling-out large-scale ICT initiatives in education (Trucano & Dykes, 2017; DepEd, 2019). However, Vergel de Dios (2016) asserts that even if the Philippine government calls for quality education through ICT, the government did not have a mandated national ICT agency until 2016. Prior to 2016, there were several loosely organized agencies, commissions, and stakeholders implementing different initiatives. There were also quasi-governmental institutions that evolved with constant changes in government leadership. Such changes not only affect the structure of the system but also its functions and funding. With numerous stakeholders and agencies involved, the coordination and management of the implementation of ICT initiatives were a big challenge. The overlapping and competing functions among agencies and stakeholders stemmed from the absence of a clear national vision and strong ICT leadership agency between 1996-2016 (Loxley & Julien, 2005; Lapus, 2006; Vergel de Dios, 2016). Due to the absence of a national benchmark in the Philippines to gauge the needs and level of competency of students and teachers in ICT, stakeholders' initiatives did not effectively address the actual needs of teachers and schools (Loxley & Julien, 2005; Hanna & Knight, 2011; Vergel de Dios, 2016). On May 23, 2016, the Department of Information and Communications Technology was officially approved as the sole department in the Philippines to "formulate, recommend, and implement national policies, plans, programs and guidelines that will promote the development and use of ICT" (RA, 2016, p. 4). It was a promulgation to finally merge all government ICT functions and initiatives into a single department. For the education sector, the Department of Information and Communications Technology was mandated to "formulate policies and initiatives in coordination with the Department of Education (DepEd) (for pre-school, elementary, and secondary schools) to develop and promote ICT in education consistent with the national goals and objectives…" (p. 5). While the current DepEd leadership is actively implementing several initiatives to improve quality education through ICT (Montemayor, 2018, 2019), there were no national benchmarks of teachers' ICT competencies that (a) align with teachers' competencies as described in the newly implemented K-12 curriculum (Parrocha, 2018) and (b) match with the ICT skills needed for teachers to implement ICT initiatives being rolled out in the classroom (Arayata, 2017).

1.2 Context

The Philippine education system is run by three independent levels of governance: DepEd, the Commission on Higher Education, and the Technical Education and Skills Development Authority (DepEd, 2019). DepEd oversees both public and private pre-school, elementary, and junior and senior high school education. It focuses on two overarching programs, namely the new K-12 curriculum and the expansion of ICT-based integrations across the curriculum. The combination of limited technical infrastructure, logistics, and the size of DepEd represents major challenges in advancing ICT in schools across the country.

For the academic school year (2019–2020), DepEd has 700, 000 teachers in 47, 000 public schools serving 21 million students (Arayata, 2017; Montemayor, 2019b), which represents almost 20% of the total population of the country (PSA, 2019a). Public schools are grouped into school divisions. A school division could cover all of the schools either in one city or in the entire province. A number of school divisions form a region. There are 17 regions (Figure 1) across the country. DepEd Region VI, Western Visayas, is located in the central part of the Philippines.

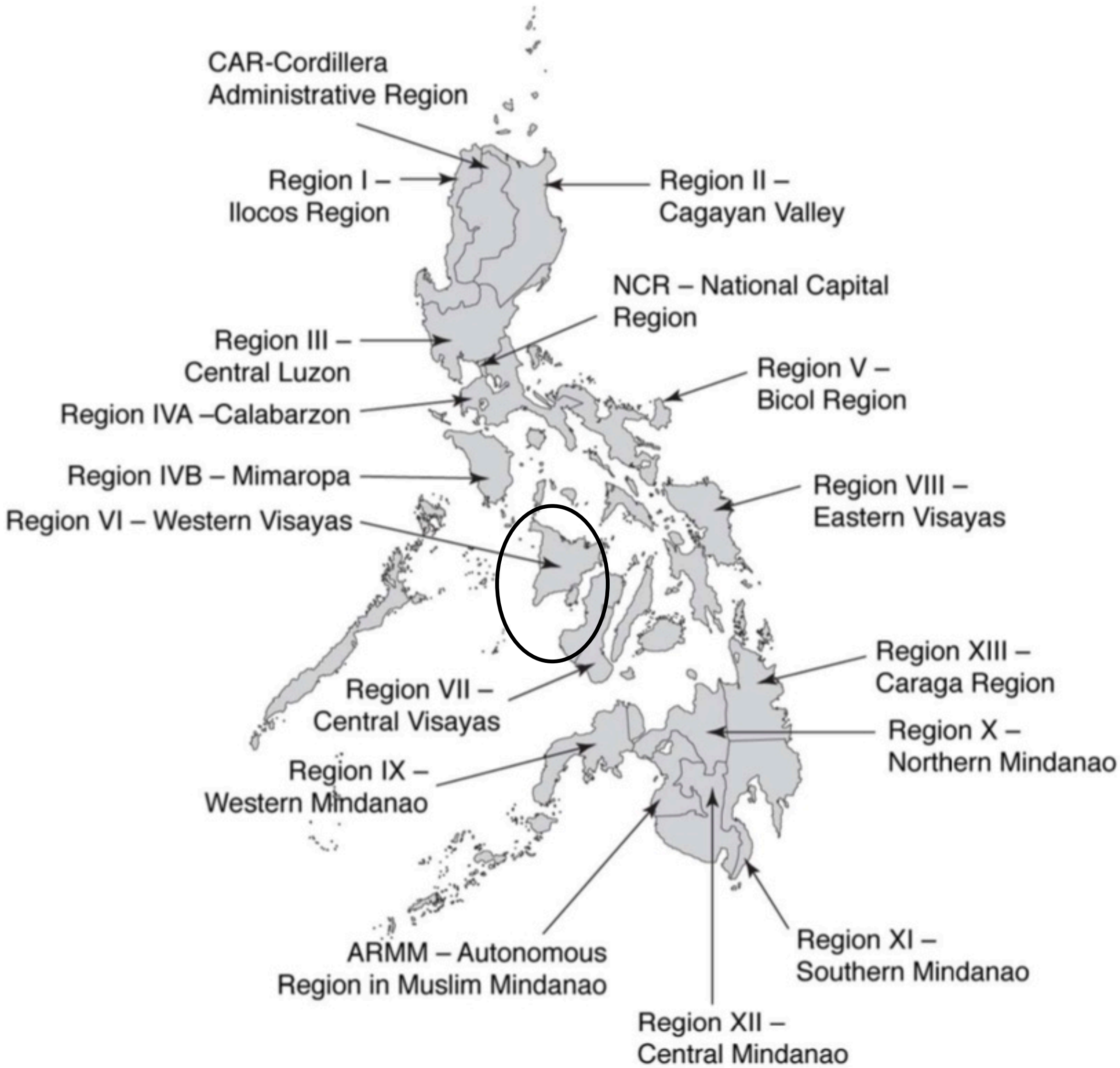


Figure 1: Maps of the Philippines showing the 17 regions (adapted from Bravo et al., 2014)

The Division of Bago City, circled below (Figure 2), is one of 20 school divisions under Region VI, Western Visayas. In this region, there are provinces which have only one school division. These are the provinces of Aklan, Antique, and Guimaras. Iloilo, the capital province of the region, has three school divisions while Capiz province has two. Negros Occidental province has

12 school divisions including Bago City. Each school is managed by its principal, while the school division is supervised by the school division superintendent. All superintendents report to the regional director, and all 17 regional directors are headed by the secretary of DepEd at the national level, who in turn serves under the Office of the President.

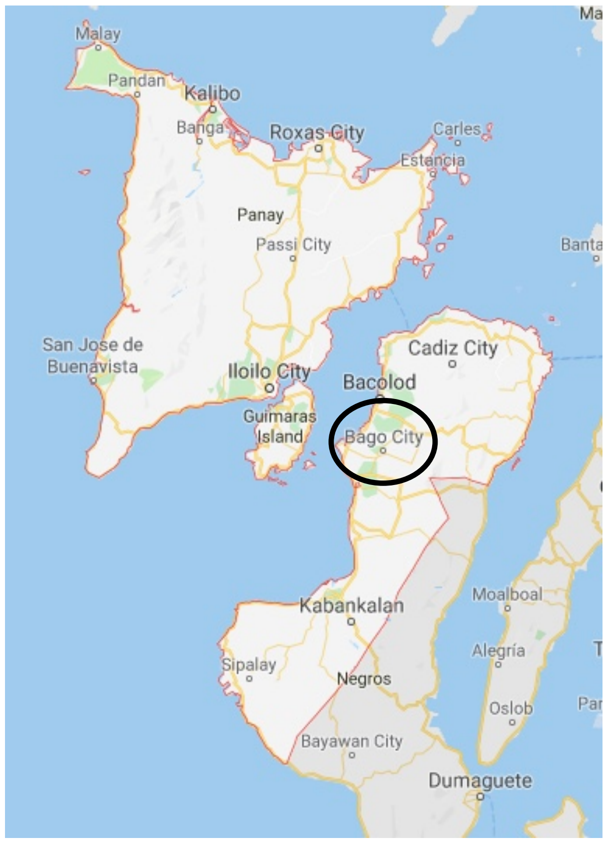


Figure 2: Map of Region VI and Bago City (adapted from Google Maps, 2019)

1.2.1 DepEd Division of Bago City, Negros Occidental: The Rural Context

The office of the school division superintendent of Bago City is situated in the city center along with city government offices. It is located 21 km south of Bacolod City, Negros Occidental, the province's capital city. Bago City is a 2nd class city, a classification based on the city's average annual income. A 2nd class city has an annual income between $8 million–$10 million (Department Order, 2008).

Bago City has 24 barangays. Barangay (PSA, 2019b; Field study, 2019) is the smallest local government units attached to municipalities and cities. Barangay can be either urban and rural. The Philippine government's classification of rural and urban is done at the barangay level. According to the official definition (PSA, 2019), a barangay is classified as urban if it meets any of the following criteria:

1.) It has a population size of 5,000 or more;
2.) It has at least one establishment with a minimum of 100 employees;
3.) It has five or more establishments with 10-99 employees, and five or more facilities within the two-kilometer radius from the barangay hall.

The facilities considered in the classification include: town/city hall or province capitol, church, chapel or mosque with religious service at least a month; public plaza, park or cemetery, market place or building where trading activities are carried out at least once a week, public building like school (elementary, high school, and college), hospital or health center, or library, landline telephone system or calling station or cellular phone signal, postal service or public fire-protection service, community waterworks system or public-street sweeper, seaport in operation.

A barangay which does not satisfy any of the criteria above is classified as rural.

The definition of "urban" has been modified since the 2000 population census as a result of rapid urbanization and while bigger cities are classified as "highly urbanized" a significant number of their populations still live in rural barangays (PSA, 2019a, Boquet, 2017).

Based on the definitions above, eight barangays in Bago City are considered urban and the remaining 16 barangays as rural. The majority of the public junior high schools that were chosen as research sites for this study are located in these 16 rural barangays (Field study, 2019).

The Division of Bago City has nine public secondary schools spread around the city. Seven secondary schools include both junior and senior high schools while two schools offer junior high school only. During my high school years, my school, was called the main high school (the biggest school in terms of student population up to the latest 2019-2020 school year) and the rest were extension high schools. Now, all schools are completely independent from the main high school. Many of these schools are surrounded by housing communities and hectares of sugarcane, rice, and corn fields with tributaries connected to Bago River. All schools are accessible via tricycle or motorcycle, which are the common means of transportation in the city for teachers and students commuting daily. For some teachers and students, reaching the schools involves riding a bus or jeepney along major provincial and city roads to reach loose terminals to access these tricycles. Tricycles leave the terminals not according to an agreed time schedule but rather based on the number of passengers they have. During the rainy season, some river tributaries swell and access to some schools becomes limited and risky, so most of the time classes are suspended during this period.

For the 2019–2020 academic year, the school division has 59 junior high school science teachers whose teaching experience ranges from one to 37 years (Field study, 2019). Under the new K-12 curriculum (SEAMEO, 2012), junior high school science teachers should teach one or more core science subject outside their expertise. For example, a science teacher who specializes in physics would also teach one or two additional subjects like general science, biology, or chemistry.

The main high school is the biggest high school in terms of its population, the best performing school, and the closest to the city centre at 1.5 km. As mentioned above, it is also my former alma mater. Four of the nine current high school principals in the division once taught at this school, while some of my former science teachers are still teaching but will be retiring in 3–5 years. The junior high school situated farthest from the city center is located 27 km away from the school division office. Except for the main high school and two other schools closer to the city centre, there is little to no Internet signal available in the rest of the schools or their nearby communities (Field study, 2019).

1.2.2 Public Junior High School Science Teachers in the Division of Bago City

Out of 45 junior high school science teachers in nine high schools, 39 participated in this study and the majority of them taught in schools in a barangay classified as rural. In terms of the number of science teachers at each school, the main high school has the most at 27, followed by another school at eight. The rest of the schools have between two and five science teachers. Nearly 50% of the teachers who joined this study are in their 1st–5th year of teaching (Figure 3). The majority of the science teachers were graduates of teacher education (Figure 4) and master's degree holders (Figure 5) (Field study, 2019).

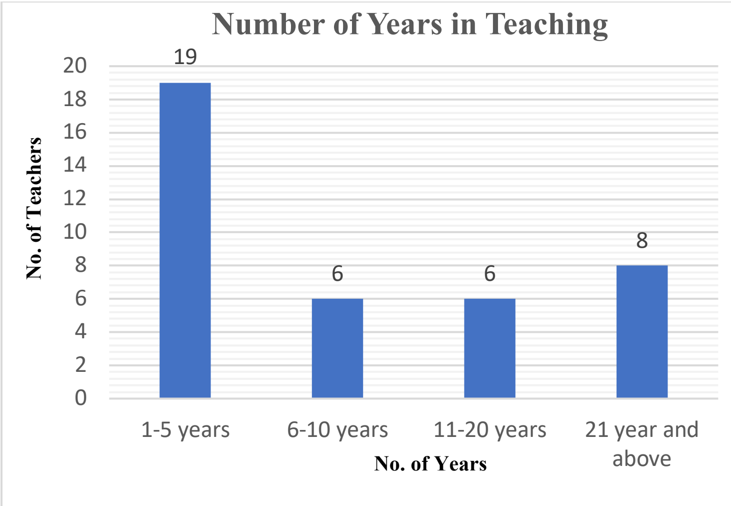


Figure 3: Number of Years in Teaching

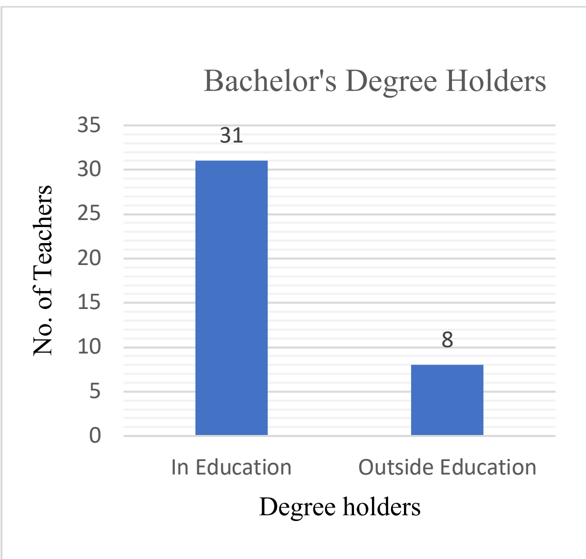


Figure 4: Bachelor's Degree Holders

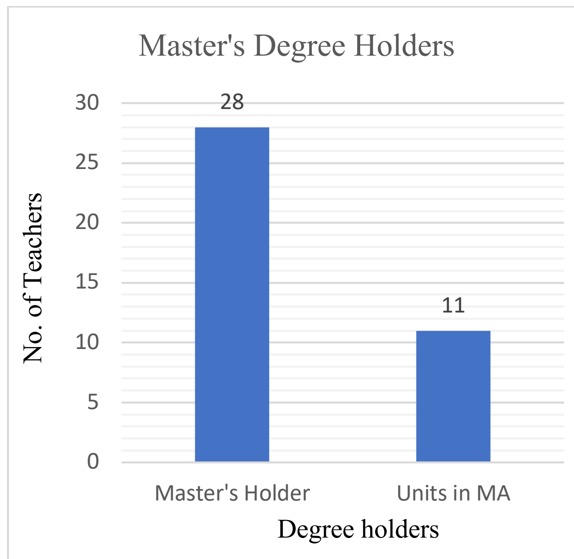


Figure 5: Master's Degree Holders

1.3 Problem Statement

While we aim to create a new society, we must not forget we are doing it with an old society.

James Yen, Founder, International Institute of Rural Reconstruction

(Flavier, 1970, p. 16)

Quoting James Yen on the pitfalls of organizations working to transform a society, Flavier (1970) endeavors to consciously understand farmers' way of life before attempting to introduce any reforms that will affect them. Similarly, if the government tries to gain insight into the quality of education teachers deliver to learners, it is important for the government to consider the actual conditions under which teachers work.

In May 2016, the Department of Information and Communications Technology was created and mandated to plan, coordinate, and administer all ICT policies in the Philippines (RA, 2016, p. 4). In December 2017, DepEd announced that eliminating the technological barriers related to ICT could be a key step toward boosting the quality of education in the country (Santisteban, 2017). In the same year, Abanil, the incoming DepEd ICT director, confirmed that DepEd would boost ICT in public schools in 2018. However, the concern is that they were still in the process of compiling teachers' profiles related to ICT competencies and matching them with appropriate training (Arayata, 2017). In 2018, DepEd announced its ICT Infrastructure Roadmap from 2018 to 2022. The roadmap included distribution of ICT packages (laptops, projectors, tablets, and digital classrooms), Internet connection, and incubation hubs (research and development centers) across primary and secondary level public schools, starting with pilot schools in selected regions in 2018–2019 (DepEd, 2019).

As DepEd's ICT initiatives are expanding throughout the country, there is a greater urgency to consolidate national benchmarks to gauge teachers' needs and levels of IT competency under the new K-12 curriculum. Moreover, under the new K-12 science curriculum, junior high school teachers are required to teach other core science subjects (earth and general science, biology, chemistry, and physics) outside their subject of specialization. The demands of using ICT across the science curriculum on top of the pressure to master content and pedagogical approaches of one or more core science subjects add to the taxing job of being a junior high school science teacher. Furthermore, DepEd faces immense challenges due to its geographical spread, limited infrastructure and funding, logistics, and size, resulting in the inequality of services delivered among urban and rural schools (Montemayor, 2019). Thus, the examination of the challenges as well as the practices of rural and remote public junior high school science teachers in their use of ICT may be critical to inform (a) ICT policies vis-à-vis science education curriculum in particular and (b) ICT policies and initiatives that match with the new K-12 curriculum in general.

1.4 Research Questions

This study was guided by the following research questions:

1) What are the experiences, including key challenges encountered by rural junior high school science teachers, during integration of ICT in their science teaching within Philippines's public high schools?
2) In what ways are these experiences related to (a) curriculum and pedagogy and (b) PD?; and
3) How are the experiences, especially the key challenges, (a) transformed into enablers of dissemination of good practices and (b) informed both institutional and government-level policy frameworks?

1.5 Significance of the Study

> *To "tech" or not to "tech" education is not the question. The real question is how to harvest the power of technology to meet the challenges of the 21st century and make education relevant, responsive, and effective for anyone, anywhere, anytime.*
>
> (Haddad & Draxler, 2002, p. 16)

ICT widens global communities' access to education, but the capacity of an implementing country in the adaption and adoption of ICT in education through its teachers draws further attention to issues of "quality, equality, and equity in education" (Lubin, 2018, p. 3). Due to limited empirical evidence showing improved educational outcomes based on technology (Lubin, 2018; Behar &Mishra, 2018), there is a pressing need to gather more research-based evidence to assess and inform ICT policy and resources for teachers to improve educational outcomes (Behar & Mishra, 2018).

This study aimed to provide empirical data related to the current challenges faced by and enabling practices of select science teachers in rural areas as they use ICT. What are the actual needs of science teachers in rural public schools as they use ICT in their respective science classes? Prior to ICT deployment in schools, if any, were teachers given opportunities in accordance with their preparedness to learn how to use ICT appropriately to support learners? Could these challenges and practices facilitate the dissemination of innovation and effective use of ICT in teaching for science teachers not only in rural areas but also in urban areas in the country and other developing countries with similar circumstances? By closely examining such challenges, this study might identify research-based findings that could serve as guidelines regarding the opportunities and challenges related to the use of ICT not only in science but also in technology, engineering, and mathematics. Such guidelines might relate to curriculum and pedagogy, teacher training programs, and continuing professional development of teachers at an institutional level. At the level of government policy, education administrators in the Philippines and other developing countries with similar circumstances could also use the findings of this study to inform their own interventions, support and framework development or improvement, and project implementation and evaluation.

1.6 Organization of the Thesis

This dissertation is organized into seven chapters. Chapter 1 (this chapter) offers an introduction to the study and describes the context, problem statement, research questions, and overall significance of the study. Chapter 2 follows with a review of literature on the emerging policies, surveys, and issues related to the use of ICT in education from an international perspective found in Sections 2.1– 2.3. The Philippine perspective on the use of ICT in education and its present challenges as well as an overview of the Department of Information and Communications Technology and DepEd's new K-12 curriculum are discussed in Sections 2.4–2.6. The technological, pedagogical, and content knowledge (TPACK) and funds of knowledge (FoK) frameworks are discussed in Section 2.7. Chapter 3 outlines the methodology for this study. It introduces case study as the methodology used, and discusses the five major elements of descriptive case study, which include the nature and context of the participants, the methods used to collect and analyze the data in order to answer the research questions, and the ethical considerations and limitations. Chapter 4 details the quantitative data analyses, then Chapter 5 deals with the qualitative data analyses. Chapter 6 outlines the results and offers discussion.

Chapter 7 culminates by discussing the answers to the study's three research questions and presenting conclusions and research implications.

Chapter 2: Literature Review and Theoretical Framework

In this chapter, I outline the overview of emerging policies across organizations and governments on the use of ICT in education from international and Philippine perspectives. I then introduce the frameworks and context of challenges used in this study.

2.1 Emerging Policies on the Use of ICT in Education

The Oxford Dictionary of Media and Communication defines ICT as an umbrella term for several media used in communicating information (Butterfield & Ngondi, 2016). In an educational context, according to this definition, ICT may cover computers, the Internet, television broadcasts, and even printed or handwritten notes. OECD (2018) categorized ICT as having three components: the information technology equipment, which includes computers and related hardware, the communications equipment, and software. A Google search (2019, Sept. 9) for the acronym ICT yielded 242 million entries and counting. These entries discussed the meaning, examples, impacts, and applications of ICT in industries, economies of the world, education, entertainment, etc.

Several international organizations (European Commission, 1995; World Bank, 1998; OECD, 1999) have published policy documents to address the profound and emerging impacts of ICT in education. For example, twenty-five years ago the European Commission (1995) underscored the importance of education and training to European society in the context of technological and economic change. In the face of technological advancement, the commission considered "guidelines for action in the pursuit of objectives to build up high-quality education and training" (p. 4). At the start of the 21st century, more policy documents were introduced and updated (UNESCO, 2008, 2018; World Bank, 2005, 2017; Wagner et.al, 2005; OECD, 2016, 2012, 2018) to meet and inform the rising demands and challenges in education brought about by ICT. The World Bank (2017) outlined examples of how technology, particularly digital technology is "changing the world of work" (p. 164). The accelerated power of computing machines, the Internet, and artificial intelligence affects the nature of work in different ways. Such acceleration of machines' power challenges world economies to prepare the workforce with critical thinking, socioemotional, and technological skills. By exploring the fast-paced rise of technology among member-nations, OECD (2018) aims to ensure "coherence in policy design and…implementation processes" (p. 26). The exploration to leverage technology for teaching and learning across OECD member and non-member countries is extremely relevant with the current Covid-19 pandemic. One of the greatest challenges is on how governments, school administrators, principals, and more importantly, the teachers can maximize modern learning technologies to support teaching and learning while schools are shut down. As the Director of Education and Skills at OECD recently suggested that "in this crisis, all teachers need to be involved, and technology allows the closing of some training gaps even during school closures" (Schleicher, 2020, para. 9).

Governments across the globe have created masterplans and national benchmarks (e.g., Singapore First Masterplan, 1997; UK-BECTA, 1998; Korea-KERIS, 1999; Australia, 2000; Canada, 2002; Hong Kong, 2004; U.S. Department of Education, 2010) in education to include the use of ICT in teaching and learning. Singapore's First Masterplan (1997) for ICT in education was formulated to prepare students for jobs that might be created as computers influenced the work and lifestyle of Singaporeans at the start of the 21st century. The British Educational Communications and Technology Agency (1998) was established with the goal of "ensuring that young people leave school and college with the ICT skills that they will need for the 21st century" (Gavin, 2017, p. 1). Korea created the Korea Education and Research Information Service (1999) in anticipation of the fundamental transformation of the traditional educational system due to the widespread presence of ICT (Youngsun Kwon, 2017). Realizing the importance of using ICT in teaching and learning, in 2002 the Conference Board of Canada designed an analytical framework to gauge Canadian schools' connectivity and ICT integration (Plante & Beattie, 2004). The U.S., with its National Education Technology Plan (2010), acknowledged that technology permeates virtually all aspects of American lives. The challenge for the American educational system is to "leverage the learning sciences and modern technology to create engaging, relevant, and personalized learning experiences for all learners that mirror students' daily lives and the reality of their futures" (p. x).

2.2 Use of ICT from SITES' Surveys: International Perspectives

Several international surveys were conducted to create comparative databases among countries and educational systems about the use of ICT in education. In 1997, the International Association for the Evaluation of Educational Achievement (IEA) began an international survey called Second Information Technology in Education Study Module 1 (SITES-M1) (Pelgrum, 2001; IEA, 2006; Law, Pelgrum, & Plomp, 2008). The objective of the survey was to gather data to help countries establish and compare their current use of ICT in education relative to other countries. The data from the survey served as benchmarks for national policymakers to consider improvements in the coming years. There were 26 participating countries from Europe, Africa, and Asia. The participants were school principals and technology coordinators who were asked to answer questions related to management support for the use of ICT vis-à-vis ICT infrastructure and support services. Two additional versions of this survey were deployed in the succeeding years. The second module was called Second Information Technology in Education Study Module 2 (SITES-M2), conducted in 2001. It was a qualitative case study on how the classrooms of 28 participating countries introduced ICT-based pedagogical approaches (Law et al., 2008). There were 174 case studies generated from this study (Kozma, 2003). These case studies offered teachers around the world examples of innovative teaching practices using ICT. For policymakers, they served as guidelines for how to further maximize the use of technology in education. The third survey was called Second Information Technology in Education Study 2006 (Law et al., 2008). The data were collected from school principals, technology coordinators, and teachers in mathematics and science in 22 participating countries. The survey was a combination of Second Information Technology in Education Study Modules 1–2. Module 1 focused on the use of ICT, infrastructure, and support services while Module 2 focused on ICT-based pedagogical practices.

Following the three international surveys in the span of a decade (1997–2006), what changes did the use of ICT in education bring to teaching and learning in schools around the world?
Based on the results of Second Information Technology in Education Study Module 1, Pelgrum & Anderson (1999) reported that a number of principals valued ICT in their schools and many schools had put in place policies regarding its use. These policies included equipment acquisition and replacement, equity of access, and Internet use. The policy on the training of all teachers in the use of ICT was achieved in only a minority of participating schools in most countries (IEA, 2006). The student-computer ratio among participating countries ranged from lower ratios (e.g., Canada with 9 to 1) to higher ratios (e.g., Cyprus with 210 to 1). In terms of Internet access,

Singapore and Iceland had 100% access, Canada 98%, and Finland 96%, while Cyprus had 11%. The problem most frequently cited by respondents was the limited number of computers, followed by teachers' lack of knowledge and skills regarding ICT (Pelgrum & Anderson, 1999; Law et al., 2006). Second Information Technology in Education Study Module 2 highlighted the innovative pedagogical practices in classrooms using ICT through a case study approach. From the 174 cases identified in the study, a substantial number of cases showed that technology was supporting teaching and learning processes through "constructivist activities" (IEA, 2006; Law et al., 2006). Teachers were seen advising students (in 90% of cases), creating structures for student activities (in 80% of cases), and collaborating with other teachers (in 50% of cases), while students were observed crafting products and mounting or staging the results of their work. The innovative ICT-based classroom practices or the so-called "constructivist activities" were found to have limited impact on other classrooms or schools. The continuity of implementation relied on varying factors like energy and commitment of teachers, availability of professional development opportunities for teachers, and administrative support. The success of the implementation of innovative ICT-based practices was reported to rely significantly on the connection between the national ICT policy and the context of such innovative classroom practices (Kozma, 2003; IEA, 2006). The third study, Second Information Technology in Education Study 2006, centered on how ICT was used in science and mathematics (Kozma, 2003; IEA, 2006; Law et al., 2006). Data showed a low percentage of teachers using ICT in teaching. Science teachers used ICT more frequently than math teachers in most countries. Result also noted that there was no correlation between the student-computer ratio and the percentage of teachers who used ICT in teaching. Moreover, it was reported that the presence of support (e.g., technical, administrative, and infrastructural) was a strong indicator of teachers' use of ICT. Besides school-level context, national curriculum policies also played a role in teachers' use of ICT.

What were the changes in investment in ICT in education among countries in the next decade after Second Information Technology in Education Study 2006? According to the PISA 2015 data as reported by OECD (2016), there were still large differences in the computer-student ratio across participating countries' education systems. There was a 1:1 computer-student ratio in Australia, Austria, Canada, New Zealand, the United Kingdom, and the United States, and at least 95% of the computers had Internet access. However, there was at least a 1:5 computer-student ratio in Albania, Algeria, Indonesia, Kosovo, and Tunisia, and less than 70% of the computers had Internet access. Moreover, data showed that among OECD countries, there were more computers per student available for learning in socioeconomically disadvantaged than in advantaged schools and more in rural than in urban schools. This was seen as a significant initiative to increase accessibility and equity of resources to disadvantaged students in rural areas who have limited access to computers and the Internet at home.

In terms of teachers' use of ICT, the common issue of teachers having limited support in their use of ICT still resurfaced in the latest Teaching and Learning International Survey (TALIS) (OECD, 2018). It showed that only 56% of teachers from OECD member-countries had training in the use of ICT as part of their teacher education certification, and only 43% of teachers expressed confidence to teach based on ICT trainings they received; 18% of teachers articulated a greater need for ICT training for teaching. As for school leaders, 25% of them declared that the deficiency of ICTs for teaching hindered the delivery of quality instruction.

2.3 Issues in the Use of ICT in Education

There is a popular idea that more educational resources increase student learning outcomes (OECD, 2016). However, several research studies (Burtless, 1996; Livingstone, 2012; Nicoletti & Rabe, 2012; OECD, 2016; World Bank, 2017) have shown that beyond a substantial level of adequacy, extra educational resources had a negligible effect in positive student learning outcomes. In a collection of essays by American education and economics professors entitled *Does Money Matter? The Effect of School Resources on Student Achievement and Adult Success,* Burtless (1996) pointed out that school expenditures have a minimal effect on students' achievement. Contributing authors to this book apparently reached a common conclusion that "no strong or systematic relationship exists between school expenditures and student performance" (p. 56). Many years later, in his foreword to a 2016 OECD report, Schleicher similarly implied that education and policy to improve student performance in schools cannot be measured only by per capita income among countries but should also include "multiple dimensions, such as: creating demanding and supportive learning environments; [and] involving parents and local communities…" (OECD, 2016, p. 3). In addition, PISA 2012 (OECD, 2012) results showed no significant progress in students' achievement in reading, mathematics, or science in member-countries that had spent the most on investments in ICT. These results suggested that the limited use of computers at school may be better than no use at all; however, it was observed that when the levels of computer use exceeded the OECD average, computer use did not translate into significant learning outcomes.

Secondly, intensifying the "availability of instructional materials in schools does not boost learning if the materials do not bridge teacher-learner engagement" (World Bank, 2017, p. 148).

For example, Sabarwal et al. (2014) pointed out that providing more textbooks in Sierra Leone in 2008 did not provide more interaction for students and teachers "because administrators put most of the books in storage—potentially to hedge against future textbook shortfalls" (as cited by World Bank, 2017, p. 148). In a study by Barrera-Osorio & Linden (2009), an increase in the provision of desktop computers to classrooms in Colombia did not impact student learning outcomes since the computers were not well integrated into the curriculum. Milner-Bolotin (2016) argued that for investments in technology to have an impact on learning, they have to be used purposely. Several interventions were not successful in increasing learning outcomes due to inadequate planning regarding how these resources would be utilized. Ganimian & Murnane (2016) added that educational infrastructures are vital to learning only when they support and bridge the teaching and learning process.

Thirdly, ICT has the potential to improve learning depending on the nature of interventions. Based on a World Bank report (2017), most of the ICT interventions have shown "no impact or—as with certain hardware interventions—a negative impact on student learning" (p. 146). For example, a computer-assisted instruction program for secondary school students in India increased math and language scores (Muralidharan, Singh, & Ganimian, 2016), while One Laptop Per Child programs in Uruguay (de Melo, Machado, & Miranda, 2014) and Peru (Cristia et al., 2017) indicated no impact on students' reading or math ability.

Fourthly, many of the ICT interventions in education "fail or stumble badly before being implemented" (World Bank, 2017, p. 146). One reason for this failure is a lack of focus on technologies that are realistically feasible in current and existing systems. For example, introducing technologies in rural school classrooms might appear more attractive "because of the weak education system…but this system itself (i.e. limited access to electricity or Internet connection) has the least capacity to support education technology interventions" (World Bank, 2017, p. 147). This example is apparent in the case of public officials in developing countries who invest highly in educational technology. They may derive "political returns from flashy technological interventions, independent of their usefulness for better learning" (World Bank, 2017, p. 147). In short, some governments seem inclined to "use ICT investments as political showcase rather than a genuine educational solution" (Vergel de Dios, 2016).

Finally, as mentioned elsewhere, although ICT use in education has the potential to impact teaching and learning (Trucano, 2016; World Bank, 2017), it also places an additional burden on teachers. In cases where developing countries' policies on ICT in education were created with a lack of robust empirical evidence and coherence in implementation, "support for teachers is often deemphasized in the early stages of ICT rollouts" (Trucano, 2016, p. 4). Even with some innovations in the use of ICT among teachers, the lack of technical and infrastructural support limits the continuation of implementation of such innovations (Law et al., 2016; Pelgrum, 2019).

2.4 ICT in Education: The Case of the Philippines

The widespread ICT initiative in education in the Philippines started under the DepEd Computerization Program in 1996 (Lapus, 2006; Vergel de Dios, 2016). The creation of the program was in line with national policies like the Medium Term Development Plan, Basic Education Curriculum, Schools First Initiative, and National Action Plan to Achieve Education for All. The 1996 General Appropriations Act (GAA) established the provisioning of IT equipment in public secondary schools, from hardware to professional teacher training (UNESCO, 2003). The government insisted that basic education should be the venue for Filipino students to expand and extend innovation and gain a global perspective through ICT. Such a perspective should be rooted in the pursuit of nation-building (UNESCO, 2003).

DepEd is the government's agency responsible for basic education (primary and secondary levels) throughout the whole country. DepEd's incorporation of information technology (IT), an older term for ICT, into the public education system across all levels was also stipulated in the National Information Technology Council's (1997) plan called "I.T. Action Agenda for the 21st century." It was a government's plan "to spur our country to global competitiveness through information technology" (p. 1). Along with this plan, DepEd identified four core areas to improve from 1996 onwards. These areas were: 1) technology integration in mathematics, science, and English curricula, 2) monitoring of performance and accountability, 3) proper funding appropriation, and 4) P.D. programs (Hanna & Knight, 2011).

From 1996 to 2012, besides DepEd, government agencies, international and non-government organizations, the private sector, and local government units had been implementing various educational ICT initiatives (Vergel de Dios, 2016). Below are listed the key players and key ICT initiatives in education in the Philippines during this period (Table 1):

Stakeholders	ICT Initiatives and Involvement
Department of Education (DepEd)	Implemented the biggest ICT education initiative in public primary and secondary schools.
Department of Trade and Industry	Donated computers to public secondary schools to promote computer-literacy.
Commission on Information and Communications Technology	Implemented "i-Schools" and "e-Skwela" as ICT-based non-formal education projects.
Department of Science and Technology	Piloted the use of tablet computers in select public schools.
State Universities and Colleges	Preferred partners for large-scale ICT education initiatives.
Foundation for Information Technology Education and Development	Assisted the promotion of Information Technology awareness in the Philippines.
Gearing-up Internet Literacy and Access to Students	A consortium of corporations, non-profit organizations, and government agencies which provided Internet access to public secondary schools and training of teachers and principals.
Intel and Microsoft	Trained 200,000 to 300,000 teachers in the Philippines between 2003-2012 on the use of technology
Australian Aid, United States of America Aid, Japan International Cooperation Agency	Bilateral donors and international organizations which funded a number of ICT initiatives in DepEd.
Knowledge Channel Foundation	A Non-Government Organization that runs the first and only educational cable channel.
Procter & Gamble	Donated one million computers to public schools as part of its corporate social responsibility initiative.
South East Asian Ministers of Education Organization-Regional Center for Educational Innovations and Technology	Known for its Text2Teach (multi-media based teaching resources done through text messages and broadcasted to TVs in the classroom and e-learning module for school administrators

Table 1: Key Players and ICT Initiatives in Education in the Philippines

The coordination and management of the implementation of large-scale ICT initiatives among several key players mentioned above presented a big challenge. The major roadblock was the absence of a clear national vision and a strong ICT leadership agency between 1996 and 2016, which resulted in several issues (Loxley & Julien, 2005; Lapus, 2006; Vergel de Dios, 2016). First, there was no alignment of projects. As reported by Vergel de Dios (2016), for instance, the Commission on Information and Communications Technology introduced open source software in public secondary schools while DepEd provided proprietary software. Second, due to the absence of a national benchmark to gauge the needs and level of competency of students and teachers related to ICT, stakeholders' initiatives did not effectively address the actual needs of schools (Loxley & Julien, 2005; Hanna & Knight, 2011; Vergel de Dios, 2016). Third, there were no project inventory initiatives undertaken to assess and update the status of projects. This created confusion among stakeholders, government agencies, and schools. For example, many schools had stopped receiving Internet service when DepEd recognized that the donor's Internet subscription was only given to schools for a year and the fees for the succeeding years would be shouldered by DepEd. In addition, there were ICT-based projects that were not scaled up despite receiving recognition from international organizations for being successful and innovative (Vergel de Dios, 2016). Other initiatives resulted in duplication of efforts or resources being unequally distributed in schools (Hanna & Knight, 2011; Vergel de Dios, 2016).

In June 2012, USAID sponsored an inventory study of completed and ongoing ICT projects in education all over the Philippines since 2000. Between 2001 and 2011, there were 64 ICT initiatives implemented, and 32 of these initiatives were evaluated (Espinosa & Caro, 2011). Espinosa and Caro (2011) revealed that initiatives were implemented in the form of infrastructure (38%), policy components (23%), training competency (21%), and curriculum-related trainings (19%). Of the initiatives, 67% were delivered in secondary schools, but most of them were not sustainable as they were meant to be pilot projects and were not continued (Espinosa & Cara, 2011). According to a USAID-funded study (Tan, 2015) on the status of Philippine public high schools related to ICT-pedagogy integration, 39% of schools were in the training stage, 50% were already in the piloting stage, and 11% were in the infusing or integrating ICT-pedagogy stage. The study recommended further enhancement of ICT competencies among Teacher Education Institutes across the country. A separate study funded by AusAid (Tan, 2015) showed that (1) public school teachers recognized ICT knowledge, exposure, training, and use as among their "ultimate needs" and (2) teachers' technical competency was adequate, but they still found using ICT to enhance pedagogy challenging. Finally, a UNESCO Teacher Readiness Survey (Tan, 2015) that included 212 responses from private (46.7%) and public (53.3%) basic education teachers (Grade 10) in 13 of the 17 regions in the country found that 1) teachers needed more training in creating multimedia resources, planning and implementing ICT-enhanced pedagogy, didactic teaching, and recording grades, and 2) they needed to be more aware of national policies on the use of ICT in education.

2.5 Department of Information and Communications Technology

On May 23, 2016, DICT was officially approved as the sole department in the Philippines to "formulate, recommend, and implement national policies, plans, programs and guidelines that will promote the development and use of ICT" (RA, 2016, p. 4). It was a promulgation to merge all government ICT functions and initiatives into a single department. For the education sector, DICT was mandated to "formulate policies and initiatives in coordination with the DepEd (for pre-school, elementary, and secondary schools) to develop and promote ICT in education consistent with the national goals and objectives…" (p. 5). In 2017, along with DICT, the government published a mid-term Philippine Development Plan 2017-2022 (NEDA, 2017).

According to this strategic plan, the government will maximize and invest in the use of core and emerging technology across all government agencies, and ICT was given the topmost priority. In alignment with this mandate, at the first nationwide DepEd ICT Summit in 2018, school administrators and ICT educators were challenged with the question, "How do we integrate technology in teaching and learning in a way that enables our students to develop 21st century skills (Trilling, 2005) and become globally competitive?" (DepEd, 2019). During the summit, DepEd encouraged school administrators and teachers to use ICT for professional development during Learning Action Cell sessions to improve teaching and learning (DepEd, 2019). Learning Action Cell is DepEd's core professional development program, and is a collaborative gathering of teachers from the same school to improve teaching and learning practices in their own classrooms (DepEd, 2016).

DepEd also announced its ICT Infrastructure Roadmap for 2018–2022. The roadmap included distribution of ICT packages (laptops, projectors, tablets, and digital classrooms), Internet connection, and incubation hubs (research and development centers) across primary and secondary level public schools, starting with pilot schools in selected regions in 2018–2019. These packages will further reduce computer to student ratios, which currently stand between 1:30 and 1:50 (DepEd, 2019), a huge improvement from the year 2006, when estimated ratios stood at an overwhelming 1:25,000 in elementary schools and 1:111 in high schools (Lapus, 2006). However, while this roadmap provides definitive direction for addressing ICT infrastructures in schools, the budget allocation for the ICT packages from 2019 to 2022 is still subject to approval (DepEd, 2019).

Despite established plans to boost ICT in public schools, Abanil, the DepEd ICT director, explained that prior to rolling out a massive ICT training for teachers, they still need to define the competencies in "ICT skills that the teachers need. From there, we would determine the training and types of programs for them" (Arayata, 2017). For the director, the limited Internet coverage and providers in the country, logistics, and the size of DepEd are the major challenges in advancing ICT in schools. For the current school year 2019–2020, DepEd is serving 27 million students with 700,000 teachers in 47,000 schools (Arayata, 2017; Montemayor, 2019).

2.6 DepEd New K-12 Curriculum

The Philippines is one of the three countries in the world that currently have a 10-year education system prior to college or university; the other two are Angola and Djibouti (Rappler, 2013). It is the last in Asia to implement a K-12 curriculum. The former DepEd Secretary described the introduction of the new K-12 curriculum as "arguably the most comprehensive basic education reform initiative ever done in the country since the establishment of the public education system more than a century ago" (SEAMEO, 2012, p. 5). The implementing guidelines of the new K-12 curriculum are mandated under Republic Act No. 1033, known as the Enhanced Basic Education Act of 2013. It provides free education for kindergarten, elementary school from Grades 1-6, four years of junior high school (Grades 7-10), and two years of senior high school (Grades 11-12). In the previous curriculum, grade school was only for six years and secondary education for four years.

In the context of this study, two features of the new curriculum will be presented. The first involves ensuring integrated and seamless learning through a spiral progression. DepEd claimed that the new K-12 curriculum (SEAMEO, 2012) provides a coherent transition of competencies and standards between grade levels through a spiral progression. In the old science curriculum, core science subjects were taught through a "discipline-based approach"—that is, biology was offered in 2nd year, chemistry in 3rd year, and physics in 4th year. Now, in the new curriculum, core science subjects are taught spirally, on a per quarter basis. For example, basic and fundamental concepts in physics are introduced in the first quarter in 1st year, and more complicated concepts and applications are added in the succeeding years until 3rd year in junior high school.

The second feature involves making the curriculum relevant to learners through contextualization and enhancement. The new curriculum strives to be relevant and responsive to the needs of Filipino learners in the 21st century. The new curriculum addresses the needs of the community; for example, a school aligns its curriculum to cater to the needs of its agricultural or coastal community. Teachers are encouraged to teach using examples and activities based on local culture, history, and reality. Learning and performance in schools should also match with current labor market standards. DepEd started the implementation of the new junior high school curriculum in academic school year 2012–2013.

2.7 **TPACK and FoK as Complementary Frameworks**

In this study, I investigated the experiences of select junior science teachers in integrating technology into their teaching through technological, pedagogical, and content knowledge

(TPACK) (Herring, Koehler, & Mishra, 2016a, 2016b) and funds of knowledge (FoK) (González, Moll, & Amanti, 2005) perspectives.

TPACK framework:

As a framework, TPACK is an expanded form of Shulman's (1986) pedagogical content knowledge (PCK). Shulman emphasized that the nature of teachers' knowledge should link the domains of content and pedagogy as one rather than treating them as separate from each other. The addition of technology into PCK's framework gave rise to the concept of TPCK (Mishra & Koehler, 2006). TPCK was then changed to TPACK to make it easy to read and remember (Thompson & Mishra, 2007). As seen in Figure 6, TPACK consolidates the three forms of knowledge—technology, pedagogy, and content—as an overlapping yet integrated whole and a "**T**otal **PACK**age" of teachers' knowledge of professional growth (Herring, Koehler, & Mishra, 2016b). TPACK is a framework that helps teachers knowingly integrate technology to enhance their teaching. It is a framework that addresses the emergence of newer educational technology and complex needs of teachers (Koehler et al., 2013). This framework has been used to interpret pedagogy in the broader field of science, technology, engineering, and mathematics (STEM). In physics education, for example, the deliberate use of technology like PeerWise online tool and Peer Instruction pedagogy improved physics teacher candidates' pedagogical content knowledge (PCK) (Milner-Bolotin, 2016, 2018, 2019). In science education, teacher education students' information literacy, inquiry skills, and science content knowledge were examined through the overlapping components of TPACK (Sheffield, Dobozy, Gibson, Mullaney, & Campbell, 2015). In math education, middle grade teacher candidates' TPACK were investigated as they overcome barriers in the access and use of technology and development of appropriate beliefs toward the use of technology (Smith, Kim, & McIntyre, 2016). TPACK posits that before teachers decide to use technology in their teaching, they have to actively and consciously determine which technology is most appropriate and relevant. This appropriateness and relevance is based on the specific needs of the students, the depth and breath of the content, the nature of the activity, the capacity and existing infrastructure of the classroom, etc.

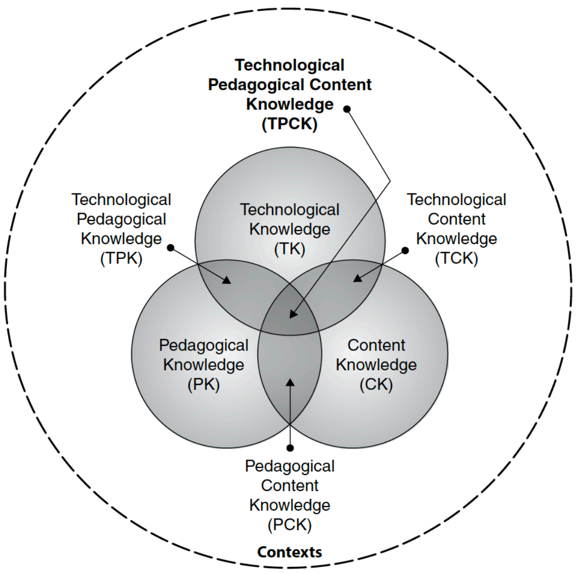


Figure 6: TPACK Framework (Reproduced by permission of the publisher © 2012 by tpack.org, 2009)

Funds of knowledge (FoK) as a framework:

Funds of knowledge are students' strengths and resources bounded within the historical, political, cultural, and social sphere of the communities to which they belong (González, Moll, & Amanti, 2005). This framework provides a call to shift the focus of our educational discourses away from high-stakes testing, national assessment, and accountability (Pinar, 2012; Biesta, 2013) and toward meaningful discourses on curriculum and pedagogy that center around students' lives as linked to their local histories and communities. Similar to TPACK, the FoK framework provides a structure to further support PD for teachers as they address the larger contextual, historical, political, and ideological environments that affect students' lives.

The earliest application of FoK in education took place in the late 1980s (Gonzalez, 1995; Llopart & Esteban-Guitart, 2018). FoK, as applied in education, involves the cultural experiences and identities of students, parents, teachers, and other immediate members of the community where the learning is taking place (González, Moll, & Amanti, 2005). FoK has been used to overcome differing perspectives in education, enhance relationships between schools and families, and show respect and value for the cultural practices of all the members of the community (Llopart & Esteban-Guitart, 2018). The recognition of students' lifestyles and cultural practices in teaching and learning builds mutual trust among teachers, students, and the wider community. Gonzalez and Moll (2002) noted that mutual trust provides a link of cooperation that can reduce prejudice and stereotypes. McIntyre, Roseberry, and Gonzàles (2001) saw it as a connection between school curricula and educational practice to the lifestyles of students. FoK as an approach to bridge students' cultural knowledge and integrate it into the curriculum involves three elements: 1) research in households and/or house visitations to identify family/cultural resources and foster trust between teachers and families; 2) classroom analysis/study of how to integrate such resources into classroom practices; and 3) study group meetings/discussions on FoK approaches, house visitations, and classroom analysis that will inform teaching and learning practices (Moll, 2014).

In this study, I chose TPACK and FoK to attend to the two features of the new K-12 curriculum discussed above: spiral progression and contextualization. In the compulsory and newly implemented K-12 curriculum of the DepEd in the Philippines, junior high school is an intermediate level between the elementary and senior high school levels. Teachers at this level handle Grade 7-10 students. It is a new level unseen in the previous curriculum, which was divided into two levels only: elementary and high school. A particularly interesting factor arises for science teachers at this new level. Previously, every science teacher was a specialist in one of the three core science subjects (biology, chemistry, physics), excluding general science. Now, every teacher must cover a quarter of every core subject at a given grade level. Once a specialist, a science teacher must now become a multi-specialist. Viewed through the TPACK lens, there is a need to assess how a science teacher navigates in teaching all core subjects. As each subject has specialized content, does a teacher have adequate subject knowledge for every core subject? How is that knowledge made accessible to junior high school students? These questions bring into examination the confidence and knowledge of a science teacher regarding how to address the conceptions and preconceptions that students of diverse backgrounds bring with them to the learning of a concept; strategies suitable to reorganize the conceptual understanding of students; forms of representations of concepts such as demonstrations and use of analogies; choices of time, place, and manner in which to engage students in learning with technology; etc.

Following TPACK's framework, a science teacher's pedagogical content knowledge of every core science subject and technology knowledge are critical to effective teaching with technology. Another issue of interest is how a teacher's TPACK comes into practice in rural schools when ICT infrastructures are inadequate. Do teachers' beliefs and attitudes toward technology influence appropriate integration of ICT when there is an inadequacy of technology in rural schools? How does school leadership improve rural school teachers' TPACK?

The lens of FoK raises conversations about rural junior high school science teachers' teaching practices that support another feature of the new curriculum—making learning relevant to learners through contextualization. According to the DepEd Learning Action Cell Order (DepEd LAC 2016), contextualization is the process of matching curriculum and pedagogy to the needs and realities of students. Linking it to the heart of FoK's perspective that learning is a social process, contextualization means that teachers respond to opportunities to connect teaching and learning in the classroom to students and communities' experiences, interests, and aspirations.

Looking at the gap in exposure and utilization of mass media and ICT among teachers, students, staff, and the community at large, how can science teachers ensure that teaching and learning opportunities inside the classroom accommodate diversity and inclusion through the use of FoK? How can teachers nurture the strengths and resources of students rooted in the evolving history and culture of the community? Using the lens of FoK, this study examined how contextualization is practiced by science teachers in rural schools to improve their PCK. The study also investigated how science teachers' TPACK broadens their knowledge about students' FoK and vice versa.

The use of TPACK and FoK in this study will provide opportunities to theorize and at the same time problematize the experiences and challenges of rural junior high school science teachers as they integrated ICT in their science classes. By examining their experiences through these lenses, this study will draw conclusions that can inform educational policy, curriculum, and pedagogy.

Chapter 3: Methodology

This chapter introduces the context and purpose of the study, and the details of the methodology and methods used to answer the research questions.

3.1 The Study

To investigate the study's research questions, I employed a nested and interpretative (Thomas, 2011, Duff, 2014, Bartlett & Vavrus, 2017) and descriptive case study approach (Yin, 1994, 2014) utilizing mixed-methods (Johnson & Onwuegbuzie, 2004). The challenges and key experiences of individual science teachers in integrating ICT in their science classes were examined within a school and viewed in relation to select science teachers in similar rural public junior high schools belonging to one division school (Bago City). As an interpretative case study, the investigation was "presented in a more ostensibly objective, detached, and decontextualized manner, reflecting distinct epistemologies and genres of conducting and reporting research" (Duff, 2014, p. 236). Quantitative methods were employed to establish:

(i) broad and revolving patterns and connections among the experiences that science teachers faced as they integrated ICT in their science teaching and

(ii) the elements of how such experiences informed curriculum, pedagogy, and the nature of PD. This was done by quantitatively analyzing the online survey questionnaire.

The questionnaire was distributed to junior high school science teachers who belonged only to the Division of Bago City and to teachers in all school divisions under DepEd Region VI. Qualitative methods were used to:

(i) provide an in-depth examination of the patterns and connections among the experiences encountered by science teachers as they integrated ICT in their science teaching drawn and analyzed from the quantitative data;

(ii) find out how such experiences informed curriculum, pedagogy, and the nature of PD;

(iii) explore existing exemplary teaching practices in the use of ICT; and

(iv) investigate how teachers' experiences can contribute to improved ICT use at both institutional and policy levels.

The qualitative methods used in this context were individual interviews, focus group discussions, and observations and reflections made during science video-creation workshop sessions. The data gathered from these methods were drawn from 60 days of fieldwork. Both quantitative and qualitative data were analyzed, triangulated, and framed in terms of TPACK and FoK. The next sections provide detailed descriptions of the case study approach, mixed-methods, quantitative and qualitative data, and data analysis.

3.2 Descriptive Case Study

Using case study, I investigated the challenges faced by the selected science teachers as they integrated ICT into their science classes. The case was about the science teachers' integration of ICT in science education in the select rural schools in the Philippines viewed through the lenses of TPACK and FoK. Gall, Gall, and Borg (2003) call case study "the most widely used approach to qualitative research in education" (p. 433). I used case study as defined by Duff (2014) and Merriam (1998). Duff (2014) explained that case study is a "thorough understanding of the phenomenon being studied" (p. 237). By looking at science teachers' challenges in integrating technology as a phenomenon, Duff's definition of a case study provides a way of conceptualizing science teachers' situations and perspectives to provide a comprehensive and detailed understanding of their experiences and insights. Similarly, Merriam (1998) conceptualizes case study as a "method or means of investigating complex social units consisting of multiple variables of potential importance in understanding the phenomenon" (p. 41). By investigating different variables involved in the challenges faced by select science teachers as a case, potential connections and paradigms might be revealed that will lead to theoretical propositions. Generating propositions that inform current and future teaching practices is the main goal of a descriptive case study in education (Tobin, 2012).

Unlike explanatory case study, which relates to research questions believed to have casual links (Baxter & Jack, 2008; Yin, 2014), or exploratory case study, with research questions needing further investigation (Yin, 2014), I chose a descriptive case study to look at the actual situation of science teachers as a phenomenon within its real-world context (Yin, 1994, 2014). In some single case studies, the three types of case study (explanatory, exploratory, and descriptive) can exist all together. One example would be Graham Allison's (1971) single case study of the 1962 Cuban missile crisis, which is considered a highly-recommended political science explanatory case study (Yin, 2014). Allison proposed theories to illuminate (explanatory) the unfolding of the U.S.-Soviet Union crisis (descriptive) and discussed how these theories might provide new perspectives (exploratory) in "post-Cold War studies of foreign policy and international politics" (Yin, 2014, p. 7). To some extent, the tendency of the three types of case study to overlap is due to the similarity of the aims of the studies (Tobin, 2012). However, the nature of a descriptive case study is distinctive in that it looks at the phenomenon and "tells it like it is" (Hackmann, 2002, p. 52) rather than attempting to "make causal statements or to describe unexplored territory" (Tobin, 2012, p. 2).

A characteristic descriptive case study that supports this argument is found in a book entitled *Street Corner Society: The Social Structure of an Italian Slum* by William F. Whyte (1955). The book presented a foundational ethnographic study in sociology that delved into the patterns of interpersonal events and subculture in an immigrant urban neighborhood hidden by the name "Cornerville" (Muschert, 2013; Yin, 2014). The remarkable discovery of how youths from lower economic status families were able to elevate their situations through career advancement and promoting neighborhood ties exemplifies this study as a classic descriptive case study reference. In spite of the fact that it was done in a small urban community and more than 100 years had passed since its publication, later case study researchers found that "Cornerville's case" still mirrors modern-day issues of "individual performance, group structure, and the social structure of neighborhoods" (Yin, 2014, p. 8).

Another exemplar descriptive case study more recent than "Cornerville" is an in-depth analysis by Neustadt and Fineberg (1978) of the immunization of 40 million Americans during the presidency of Gerald Ford (1974-1977). The unprecedented immunization was initiated to ward off fears of an outbreak reminiscent of the virus that brought about the worldwide 1918–1919 flu pandemic. It started when the suspected swine flu virus infected a small number of soldiers at Fort Dix, New Jersey. The widespread immunization campaign extended to 40 million Americans in 10 weeks, but the virus never resurfaced. The controversial program was mired in delays, administrative and legal complications, etc. In the hopes of extracting lessons for future eventualities, Neustadt and Fineberg were requested by Department of Health, Education and

Welfare head Joseph Califano to investigate what really happened. Their findings were reported as "The Swine Flu Affair: Decision-Making on a Slippery Disease" in 1978. It became a highly valuable case study reference for policymakers, scientists, and the general public as "generalizable lessons for understanding the quandaries of health crises and public actions in light of new threats by flu epidemics, such as the H1N1 strain of 2008-2010" (Yin, 2014, p. 8).

One of the celebrated descriptive case studies in science education was the 'Case Studies in Science Education; Vol. 1&2' conducted by the University of Illinois as awarded and funded by the National Science Foundation to Stake and Easley (Stake & Easley, 1978). It was a "collection of field observations of science teaching and learning in American public schools during the school year 1976-1977" (p. 6). The case was about the science teaching and learning in American public schools during the school year 1976-1977. The results of this case study had crucial implications for policy and research in the curriculum field at that time and were viewed as pivotal to the several case study research conducted in the United States in the years that follow and even up to the present.

3.3 Case Study as a Research Design

Case study is the most common research design used in educational technology (Ronau & Rakes, 2012). Gerring (2004) labelled it as "best defined as an intensive study of a single unit (a relatively bounded phenomenon) where the scholar's aim is to elucidate features of a larger class of similar phenomenon" (p. 341). While several researchers (Harding, 1987; Sjoberg et al., 1991; Stake, 2005; Yin, 2003, 2014) categorize case study as a research design, others classify it as a method or methodology (Hamilton & Corbett-Whittier, 2013; Bassey, 1999; Merriam, 1988; Orum, Feagin, & Sjoberg, 1991; Yin, 1994). VanWynsberghe & Khan (2007) provide further discussion on how several authors vary in their classification of case study as a research design, method, or methodology.

Yin (2014) outlines five aspects of the research design that are critical to support methodological and design decisions under descriptive case study. These include the **research questions, study propositions, the unit(s) of analysis, the connection between the data and the propositions (data collection procedures), and the data analysis techniques.**

The application of these elements in this study is discussed below.

3.3.1 Research Questions

This study explored the following research questions:

1) What are the experiences, including key challenges, encountered by rural junior high school science teachers during integration of ICT in their science teaching within Philippines's public high schools?
2) In what ways are these experiences related to (a) curriculum and pedagogy and (b) P.D.?; and
3) How are these experiences, especially the key challenges, (a) transformed into enablers of dissemination of good practices, and (b) informed both institutional and government-level policy frameworks?

3.3.2 Study Propositions

Propositions guided me to narrow my focus, connecting and balancing particular aspects of the study with the whole rather than looking at every aspect of the study, which is impossible to achieve (Stake, 2005). Propositions are supported by the assumption that all my research questions may not sufficiently address all that I need to study (Yin, 2014). The propositions I included are as follows:

Proposition #1: The select science teachers might openly discuss the challenges they faced in using ICT in their science classes when I engage with them as collaborator and co-creator of knowledge. To do this, I conducted my 60-day fieldwork in the schools and with the science teachers guided by the principles of the Philippine Rural Reconstruction Movement. The former Secretary of the Department of Health, Dr. Juan Flavier, popularized this movement by living and serving as a "doctor to the barrios" among the barrios (villages) and communities in the countryside (Flavier, 1970). Together with the principles of the movement, science teachers' existing situations can be further captured by looking through the lenses of TPACK and FoK frameworks.

Proposition #2: The experiences and challenges faced by science teachers in integrating ICT in their teaching might relate to different and overlapping issues in curriculum, pedagogy, and P.D.

3.3.3 The Unit of Analysis and Case Selection

The unit of analysis in this case study is the group of select science teachers in eight of the nine public junior high schools under the Division of Bago City, Negros Occidental, Philippines. The analysis will focus on teachers' challenges as they integrate ICT in their science classes. Analysis was done with teachers as individuals and as a group (Yin, 2014).

Selection of the Case

> *If you are going to do a case study, you are likely to devote a significant portion of your time to that case study…therefore, in using the case study method, your goal should be to*

select your case study carefully. ..The more significant your case…the more likely your case study will contribute to the research literature or to improvements in practice (or to completion of a doctoral dissertation).

(Neustadt & Fineberg, 2004, p. 3–4)

Neustadt & Fineberg (1978) are the authors of a government report titled "The Swine Flu Affair: Decision-Making on a Slippery Disease," a celebrated descriptive case study of a swine flu scare in the United States. In 1983, they titled their book about this apparent threat of a world epidemic *The Epidemic That Never Was.* With regard to the subject of selecting a case, both authors recommended choosing the "most significant case possible" (Neustadt & Fineberg, 2004, p. 4). A properly selected case study, according to them, might produce outstanding results, which in turn could provide new theories or understanding.

In this study, the challenges of selected Philippine public junior high school science teachers as they integrated ICT in their classes were emphasized in this case study due to radical changes and overlapping tides of events in the recent history of public education in the Philippines.

Firstly, DepEd introduced the Enhanced Basic Education Act of 2013 (EBEA) or the so-called K-12 reform in 2016, of which the recent government of President Rodrigo Duterte was initially skeptical (Oxford, 2017). The introduction of an extra year at the elementary level and the switch to three years of junior high school and two years of senior high school from the previous total of four years of high school created enormous re-organization, re-staffing, and re-alignment of funds, resources, curriculum overhauling, etc. (Hernando-Malipot, 2019a, 2019b).

Secondly, in the same year, a new national department, DICT, was implemented to lead all ICT policies and initiatives in the country (Vergel De Dios, 2016). The transition to the new department and its bearing on DepEd's ICT initiatives and flagship projects have potential impacts for all public schools in the country, particularly for all junior high school science teachers. Thirdly, the year 2016 was also the year when the new President, Rodrigo Duterte, took office, bringing with him new leadership changes under DepEd. Currently, the new leadership and the newly implemented K-12 program are faced with budget constraints (CNN, 2016; Hernando-Malipot, 2019c).

Lastly, DepEd is investing highly in its computerization program and contextualization (i.e., use of Indigenous knowledge and situating academic subjects in the context of the students). All these developments have placed an increasing demand on all junior high school science teachers, who, unlike their counterparts at the senior high school level, have to teach all the core science subjects (general science, biology, chemistry, and physics) in a spiral progressive manner.

The selection of seven schools was done using convenience sampling (Bartlett & Vavrus, 2017) with the following favourable circumstances:

1) **Representativeness of Philippine public junior high schools**. The schools chosen in the study are a mix of performing, improving, and relatively new public junior high schools. The main high school is a performing public school whose students and/or teachers are consistently leading, participating, and winning in division, regional, and national level competitions, initiatives, and conferences. Schools that are improving are those schools whose teachers and students are consistently striving to participate in division, regional, and national level competitions, initiatives, and conferences. One junior high school, the farthest from the city

centre, is the newest school among the schools chosen in this study. It began operating as an independent junior high school in its first academic school year (2019–2020) after being an extension high school for a number of years (Field study, 2019).

2) **Resources**. The selected schools have a wide range of differences in terms of accessibility and inaccessibility of instructional materials, student and teacher populations, quality, training exposure, teaching experiences of science teachers, and teaching facilities. For example, some schools can access the Internet via personal subscriptions due to the presence of nearby telecommunication sites, while teachers from other schools have to leave their school and go to a nearby town market or city to access the Internet and send the documents needed by DepEd. The main high school has separate science laboratory rooms while most of the other high schools do not.

3) **Administrative support**. All the selected schools have principals and heads of schools that were open to providing assistance with my case study research. This assistance was in the form of communicating and disseminating my research schedules and plans to the science teachers and provisioning classrooms and meeting rooms for interviews, focus group discussions, and science video-creation workshops.

4) **Accessibility**. All the host schools were accessible by bus, jeepney, and tricycle.

5) **Language**. As a native of this province, I speak the dialect of the town. Thus, I have the capacity to understand the expressions, terminologies, and nuances that might otherwise be lost or limited due to the context, unique experiences, and limited English proficiency of some teacher-participants during my fieldwork.

3.3.4 Data Collection Procedures

Data collection for this study is guided by combined quantitative and qualitative methods, also known as mixed-methods or mixed-model research (Johnson & Onwuegbuzie, 2004). A mixed-methods toolbox combines the strengths of both methods and permits the researcher to bring into focus a wider perspective on the phenomena under study. This method is more integrative than just a combination of qualitative and quantitative data (Watkins & Gioia, 2015). Watkins and Gioia (2015) emphasize that the integrative feature of a mixed-methods approach is that we draw our analysis and interpretations from the data we have gathered as guided by the research questions and methods to impact social work research, practice, and policy. In addition, a combination of high quality quantitative and qualitative methods can inform the research process at every level from exploration to evaluation (Trevas & Nimkoff, 2015).

I adopted and adapted mixed methods in this study to invite the interplay of conversations, theory, and numerical data on the challenges of science teachers integrating ICT in their teaching. I found that maximizing the strengths of both methods (quantitative and qualitative) contributed to the trustworthiness (validity) criterion valued in qualitative methods (Lincoln & Guba, 1985) and internal and external validity sought in quantitative methods (Johnson & Christensen, 2000). The strengths of mixed methods are drawn from the three different worldviews evolving around my developing identity as a researcher in connection to my research sites and participants. These worldviews include:

(1) A positivist worldview—characterizing the reality of the challenges of science teachers as single, objective, and fragmented (Creswell, 1994, 2003). This worldview will focus on

exploring the factors involved in the challenges science teachers face—testing, measuring, and analyzing the data statistically. The statistical results are viewed as objective facts;

(2) A naturalistic worldview—looking into the meanings and nuances of science teachers' experiences and insights and how they make sense of the challenges they are facing (Lincoln & Guba, 1985; Denzin & Lincoln, 2000; Duff, 2014). The data and generated analysis in this worldview are seen as a co-construction of knowledge in the context of a community; and

(3) A pragmatic worldview—viewing both qualitative and quantitative data of science teachers as parallel or sequential, compatible, and able to be used in a single research study (Tashikorri & Teddie, 2003; Johnson & Onwuegbuzie, 2004; Kitchenham, 2019).

3.3.4.1 Quantitative Methods

Development and Deployment of the Questionnaire

I developed an online questionnaire (Appendix A) to provide school division and regional level perspectives on the challenges of public junior high school science teachers as they integrated ICT in their classes. Prior to deployment, the questionnaire went through item selection, organization, and a face validity process (Hesse, 2018). Item selection was done by identifying and creating items that address the research questions and are grounded in the theoretical lenses (TPACK & FoK) of the study. The questionnaire was a self-administered instrument. It consisted of 36 items with three different item types:

(1) open-ended questions;

(2) Likert-type ratings of agreement and disagreement items; and

(3) multiple choice questions.

Table 2 provides representative examples for each type of item. For example, item D6 is an open-ended question that asked about junior high school science teachers' understanding of technology in the context of science teaching. All questions labeled D asked for the demographic profiles of science teachers. There were 10 more items similar to D6 that described teaching practices or experiences over a specific time frame. This allowed responses from all science teacher-participants to converge in a common time frame; thus, a question can capture a collective representation of responses. For example, with the widespread use of laptops among public school teachers, D9 is a sample multiple choice item that aimed to find out different ways teachers use the device for instruction over a period of four weeks. Q1 was a sample of a Likert-type scale question. It solicited teachers' opinions on the notion that integrating technology in science class improves teacher-student interaction.

Q1. I am convinced that integrating technology in science teaching improves teacher-student interaction. Strongly Agree Agree Neutral Disagree Strongly disagree **D6.** Someone used a metaphor to describe technology as "crossing the river without getting my feet wet". Others described technology by citing the efficiency of MS Excel in computing for students' grades. As a science teacher, how do you define technology? **D9.** In what ways do you use your laptop in your science class? Which one did you do most frequently for the last four weeks? To show a video about a science concept, through online link or PowerPoint To show diagram, pictures, or illustration of science concept To send emails, announcement to students For online quiz, games, puzzles For assignments, short quiz Others **D13.** What were the ideas, concepts, beliefs, and practices related to the community, students, students' families, students' history and culture, etc. that you have used in your science class inside and outside the classroom to help students understand or appreciate science concepts and theories for the last two grading periods? Multiple answers allowed. Parents', grandparents' and elder people's experience and wisdom Religious symbols, beliefs and practices – fiesta, festivities, etc. Professions, jobs, hobbies within the barangay/community Lands, rivers, seas, mountains, hills, landscapes, etc. Local and indigenous music, news, sports, arts Local agriculture, fishing, business practices Gender, marriage, religion, laws

Table 2: Sample Items from the Questionnaire

The contents of the instrument were created based on the following references:

i) **TPACK and FoK frameworks**. The TPACK framework interlinks technology, pedagogy, and content knowledge to enhance teaching and learning (Herring, Koehler, & Mishra, 2016a). This framework primarily conceptualizes the deliberate use of technology (Milner-Bolotin, 2016) and provides indicators on the comprehensiveness of teacher's PCK (Shulman, 1986). This survey instrument was framed to find out the interplay of science teachers' TPACK proficiency. Moreover, as science teachers are further encouraged to teach science in the context of students' experiences and perspectives, the instrument included items to measure the extent of FoK (González, Moll, & Amanti, 2005) they use.

ii) **International comparative assessments**. There are several international comparative assessments that look into the impacts of ICT on education. Most of these assessments concentrate either on how ICT enhances teaching and learning or on the extent of investments in and use of ICT in schools for educational policy reforms (T. No., 2009). Examples include SITES-Module 2 (Pelgrum, 2001; Kozma, 2003), PISA, and OECD (2012, 2016).

The questionnaire was administered to eight out of nine junior high schools in the Division of Bago City. It was also sent to all 19 school divisions in the whole Region VI to reach as many science teachers as possible. The questionnaire was deployed and retrieved via the UBC Qualtrics online survey platform (Survey Tool, 2019).

The items were organized in an inverted funnel format, moving from specific to narrow followed by general questions at the end. Organizing the questions is crucial so as to minimize skewed responses due to a redundancy effect (Hesse, 2018). This effect is seen when items seem to be identical and repetitive so participants tend to lose concentration or skip them. Another pitfall is fatigue effect, where participants become drained from answering several long questions.

Fortunately, similar to current online survey platforms, the UBC Qualtrics survey tool has a built-in expert review matrix that provides feedback on the type of items in the questionnaire, which I also used as a guide prior to deployment. The face validity process was done as described in the next section.

Questionnaire Validity

Prior to the administration of the online questionnaire instrument, the content was subjected to validity and reliability tests. Generally, a validated instrument means that it can measure what it is designed to measure. In educational measurement literature, validity is defined as “the degree to which evidence and theory support the interpretations of the test score for the proposed uses” (AERA, APA, & NCME, 2014, p. 11). For Knekta, Runyon, and Eddy (2019), validating a survey is also time-sensitive, particularly with instruments that focus on issues like technology. Technology is fast evolving, and a survey about technology created in the 1970s or 1980s might appear obsolete if adopted and deployed in the current time. Considering the above descriptions of validity, I asked researchers and practitioners who are currently and actively involved in education and educational technology to validate my instrument. The reviewers included: 1) two members of my PhD Committee; 2) two public high school principals in the Philippines; and 3) two practicing public junior high school science teachers in the Philippines. Comments from short individual interviews with those who joined the validation tests were used to improve the content, wording of questions, type of response scales, and context of questions, and reduce the length of time (approximately 3-5 minutes) of answering the instrument . As a result, the questionnaire was reduced from 40 items to 36 items. The items were now composed of (a) 15 items that asked for demographic profiles (both open-ended and multiple type items) and (b) 21

Likert-type ratings of agreement and disagreement items (Strongly agree =1, Agree = 2, Neutral = 3, Disagree = 4, and Strongly Disagree = 5) that described potential aspects of science teachers' challenges as they use ICT in school.

Questionnaire Reliability

A reliability test is undertaken to determine the extent to which items in an instrument can measure expected output when these items are repeated. In another words, reliability measures the applicability and consistency of the instrument's measurements (AERA, APA, & NCME, 2014). Cronbach's alpha (α) is a common estimate of internal reliability of items in a scale such as the Likert scale (Cronbach, 1951; Cronbach & Shavelson, 2004; Vaske, Beaman, & Sponarski, 2017). Cronbach's alpha values range from 0.00 to 1.0, and if items in the instrument do not correlate among themselves, then the value can go negative. The issues among statisticians and researchers relative to Cronbach's alpha are: (1) what represents an acceptable size for Cronbach's alpha, since alpha depends on the quantity of items in the scale (Vaske, Beaman, & Sponarski, 2017), and (2) in what manner alpha values are reported, particularly in the context of science education (Taber, 2018). It is a common observation that Cronbach's alpha is frequently used in science education research. However, researchers "often cite alpha values with little commentary to explain why they feel this statistic is relevant and seldom interpret the result for readers beyond citing an arbitrary threshold for an *accepted* value" (p. 1273, emphasis in original). In this study, the internal reliability or consistency of the questionnaire was measured from the responses of five public junior high school science teachers coming from the different school divisions in Region VI. The 21 Likert-type items were analyzed for internal reliability. These items sought to find out how public junior high school science teachers view the use of technology (TPACK) and contextualization (FoK) in their classes and the extent of DepEd's ICT policies, support, and initiatives in their own respective school divisions. Using SPSS version 23, the computed Cronbach alpha value was 0.86 (Table 3b), equivalent to good internal reliability and 0.4 shy of the highest rating of 0.9 as excellent. The 0.86 internal reliability meant that the five science teachers agreed that 86 % percent of the 21 items reflect the actual contexts (to be discussed in detail in Chapter 4) they are facing as regards the use of technology (TPACK) and contextualization (FoK) in their classes and the extent of DepEd's ICT policies, support, and initiatives in their own respective school divisions.

a.) Case Processing Summary

		N	%
Cases	Valid	5	100.0
	Excluded[a]	0	.0
	Total	5	100.0

a. Listwise deletion based on all variables in the procedure.

b.) Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.863	.852	21

c.) Item Statistics

	Mean	Std. Deviation	N
Q1	1.4000	.54772	5
Q2	1.2000	.44721	5
Q3	1.2000	.44721	5
Q4	1.4000	.54772	5
Q5	2.0000	.70711	5
Q6	2.0000	.70711	5
Q7	2.2000	.83666	5
Q8	2.4000	1.14018	5
Q9	2.6000	1.14018	5
Q10	2.4000	1.14018	5
Q11	3.0000	1.22474	5
Q12	2.0000	.70711	5
Q13	2.2000	.83666	5
Q14	1.8000	.44721	5
Q15	1.8000	.44721	5
Q16	1.8000	.44721	5
Q17	2.0000	.70711	5
Q18	2.0000	.70711	5
Q19	2.0000	.70711	5
Q20	2.2000	.44721	5
Q21	2.2000	.44721	5

Table 3: Questionnaire's Internal Reliability

The 21 Likert-type items in the study were also subjected to a test of interrater reliability; that is, the extent to which raters (data collectors, researchers, participants) agree to the same item or variable being measured (Mchugh, 2012). Two public junior high school science teachers were asked to rate to what level the items represent science teachers' views on the use of technology (TPACK) and contextualization (FoK) in their classes and the extent of DepEd's ICT policies, support, and initiatives in their own respective school divisions. The extent of agreement (interrater reliability) between the two raters is called Cohen's kappa (Mchugh, 2012). The Cohen's kappa was computed using SPSS version 23. The result was 0.75 (Table 4c). A Cohen's kappa of 0.75 indicates that two teacher-raters have substantial agreement, whereas if the value had further increased to 0.81 and higher, it would have meant that raters have almost perfect or prefect agreement (Hallgren, 2012). A Cohen's kappa of 0.75 specifically meant that the teacher-raters have substantial agreement that the 21 sub-items can describe and measure different aspects of the challenges teachers face as they use ICT in public junior science high schools.

a.) **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Rater_1 * Rater_2	21	100.0%	0	0.0%	21	100.0%

b.) **Rater_1 * Rater_2 Crosstabulation**

Count

		Rater_2			Total
		2.00	3.00	4.00	
Rater_1	2.00	6	2	0	8
	3.00	1	10	0	11
	4.00	0	0	2	2
Total		7	12	2	21

c.) **Symmetric Measures**

		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	.747	.139	4.272	.000
N of Valid Cases		21			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Table 4: Questionnaire's Interrater Reliability

3.3.4.2 Qualitative Methods: Interviews, Workshops, and Notes

Interviews

I employed interviews with both individuals and focus groups (for the complete list, kindly refer to Appendix B) to gather in-depth understanding of phenomena or experiences (Lincoln & Guba, 1985; Denzin & Lincoln, 2000) faced by science teachers as they use ICT in their classes. I used Duff's (2015) proposition on the purpose of interviews although it was written in the context of transnationalism, multilingualism, and identity in applied linguistics research. She said that observation and interview-based case studies have the "potential to reveal, with sufficient contextualization and detail, the practices, ideologies, tensions, contingencies, and dilemmas that a small number of selected transnational individuals and families may face in their lives in connection with language" (p. 62). Such a statement seemingly mirrors the potentialities of interviews in my study to uncover the challenges faced by science teachers related to technology, pedagogy, content, and use of funds of knowledge in their teaching.

Semi-structured One-on-One Interviews

This type of interview is the most frequently used type of interview in social sciences using qualitative methods (Elliot et al., 2016). It provides chances for the interviewees to discuss ideas and broad topics more openly compared to a structured interview. The science teachers in this study were interviewed using a semi-structured interview protocol with the prior understanding that we could change the order and level of questions, offer follow-up questions and clarifications, and take a break anytime. The questions (Table 5) raised in the interviews were formulated based on the initial propositions of this study, responses from the questionnaire, literature review, and my personal past experiences of being a high school teacher myself and a former student of this school division. The interviews were conducted after teachers had completed the questionnaire. The average interview ranged from 40 to 60 minutes. The interviews took place Dec. 5–12, 2019. There were nine teachers interviewed coming from eight schools.

<u>**One-on-one Interview Questions**</u>
1. Why did you answer that these (from UBC Qualtrics Survey) are the common problems you encountered every time you use tools/gadgets in your science class? 2. What were the trainings/workshops did your principal/department head asked you to participate for the last 3 years? 3. Have you attended all of them? Why and why not? 4. What were the things you learned that helped you improve your teaching? 5. What were the things you wished you learned in those trainings/workshops? And why? 6. How important is it for students in science to integrate <u>**ideas/concepts/beliefs/practices**</u> related to the <u>**community, students, students' families, students' history/culture**</u>?

Table 5: Sample Interview Questions

Focus Group Interviews

The focus group interviews were conducted to allow science teachers to discuss their communal experiences, perspectives, and beliefs (Krueger & Casey, 2010) as they integrated ICT into their classes. The sessions were avenues for science teachers to reflect on their practices in relation with other teachers' practices (Dilshad & Latif, 2013). There were five separate focus group sessions conducted from Dec 5, 2018 to Jan. 12, 2019 with teachers from five schools. The duration of sessions ranged from 40 to 60 minutes, and the group size was between three and five science teachers. As with the one-on-one semi-structured interviews, the questions (Table 6) were formulated from initial propositions of this study, responses from the questionnaire, literature review, and my personal past experiences of being a high school teacher myself and a former student of this school division.

Focus Group Questions 1. Why is it that most of you mentioned that these (from UBC Qualtrics Survey) are the common problems you encountered every time you use tools/gadgets in your science class? 2. How can you keep up yourself as a teacher with your students in terms of being confident and knowledgeable in using these tools/gadgets/computers/APP/etc.? 3. In what way can your school administration and the division in general help/assist you to level up your knowledge and confidence to use technology in your science class? 4. How do project on 2-3 years from now? a) What programs or training/workshop will the school/division offer on ICT? b) Your level of confidence and knowledge in using ICT c) Any support that your school administration will provide

Table 6: Sample Focus Group Questions

Science Video-Creation Workshops Integrated with Observations and Reflections

The introduction of science video-creation workshops was funded by the UBC Graduate and Postdoctoral Studies Public Scholar Initiative (PSI, 2018). As a PSI scholar, the focus of my scholarship is through a holistic concern about how knowledge can make a difference in the community. Part of my research at PSI aimed to clarify and build upon significant aspects of my dissertation about the difficulties encountered by STEM teachers in rural areas in the Philippines as they integrate local knowledge into digital video productions.

The science video-creation workshops (Appendix C) were composed of spiral progression sessions as follows: (1) taking, editing, and annotating screenshots of still pictures; (2) recording and editing audio and video clips; and (3) pre-production, production, and post-production of a 3–5 minute science video. The media used in the workshops were taken from science teachers' personal files (photos and videos of the local community e.g., plants, animals, rivers, etc. taken using their smartphones) and from the Internet with proper citations. The software and hardware used in the workshops were licensed and provided free of charge for the teacher-participants. These included Camtasia and Snagit (TechSmith, 2018) for the photo, audio, and video-editing software. The software was downloaded and run on science teachers' own laptops. There were nine sessions conducted with each session lasting 2–5 hours. The workshop sessions were given per school and the number of science teachers who participated in each school ranged from one to four. The workshops were given to five schools (two schools had more than one session) between Jan. 3 and 15, 2019. The workshops' schedules including those for interviews and focus groups are presented in Table 7. The contents of the workshop aligned with the research questions of this study and were validated by my PhD committee. I conducted all the science video workshops. The workshop participants were also research participants who signed up.

Date	**Location (Exact name withheld)**	**One-on-one Interview**	**Focus Group (no. of teachers)**	**Science Video Creation Workshop (no. of teachers)**
Dec. 6, 2018	School 1	1		
Dec. 7, 2018	School 2		2 (3, 4)	
Dec. 8, 2018	School 3	1	1 (3)	
Dec. 9, 2018	School 4	3		
Dec. 11, 2018	School 5		1 (5)	
Dec. 12, 2018	School 1	1		
	School 6	1		
Dec. 13, 2018	School 7	1	1 (3)	
Jan. 3, 2019	School 2			1 (4)
	School 7			1 (2)
Ja. 4, 2019	School 2	1		1 (3)
	School 8			
Jan. 9, 2019	School 3			1 (3)
Jan. 10, 2019	School 7			1 (3)
	School 2			1 (3)
Jan. 11, 2019	School 4			1 (1)
Jan. 15, 2019	School 1			1 (1)
Total		**9**	**5 (18)**	**8 (20)**

Table 7: Schedules: Interviews, Focus Groups, & Workshops

With respect to science movie creation, I have a combined two years of experience as a Technology Support Staff member and Graduate Research Assistant in the Faculty of Education in Educational Technology Support (ETS) with the UBC Department of Curriculum and Pedagogy (EDCP). The mentorship of my supervisor, Dr. Milner-Bolotin, has helped me further integrate digital technologies into the pedagogical practices of teacher candidates in the Teacher Education Program (Tembrevilla & Milner-Bolotin, 2019). I facilitated video editing and coding workshops for science and physics teacher candidates in Vancouver. My supervisor and I created 50 STEM videos for K-12 teachers, teacher candidates, and students (Milner-Bolotin, 2017). These videos have been viewed on YouTube by people in more than 35 countries.

The science video-creation workshops in this study were conducted to find out the skills and interests of science teachers related to the use of ICT, how they used ICT based on their content and pedagogical needs (TPACK), and the extent to which they integrated FoK through science videos. Through these science video-creation workshops, teachers can manifest implicitly and explicitly the challenges they have in using ICT, how and when they used local knowledge with ICT in their science classes, the extent of administrative support received, and the nature of professional development they have in their respective schools and in the school division as a whole. I kept written observations in the form of field notes and memos, and collated science teachers' reflections before, during, and after the workshops.

Researcher Notes

The written notes I recorded are field notes and memos. Field notes contain my "private, personal thoughts, ideas, and queries regarding [my] research observations and interviews" (Phillippi & Lauderdale, 2018, p. 381). They enrich my data for in-depth contextualization and understanding (Patton, 2002; Creswell, 2013) of the science teachers' challenges as they use ICT in their classes.

My memos were divided into two types; procedural and analytic (Myers, 2009). Procedural memos describe the paths and steps I used in gathering my data. Analytical memos are the notes and comments I made while reading or writing the interview transcripts, codes, written observations, and reflections of teachers in the science video creation workshops. These memos enabled me to "step back from the data and move beyond codes" (Miles & Huberman, 1994, p. 72).

3.3.5 Data Analysis Techniques

The last of the five core aspects of this descriptive case study design, which started with research questions, study propositions, units of analysis, and data collection procedures, is data analysis techniques. This aspect will describe the "specification and justification of the methods to be used to reduce and analyze the data" (Blaikie, 2010, p. 25).

3.3.5.1 Quantitative Data Analysis: Exploratory Factor Analysis (EFA)

In contrast with the qualitative data analysis done in this study, quantitative analysis seeks to quantify a phenomenon rather than focusing on meanings (Denzin & Lincoln, 2000; Patton, 2002). As described in Section **3.3.4.1**, the questionnaire was sent to junior high school science teachers in the school division of Bago City and the rest of the school divisions in DepEd Region VI. The aim of the questionnaire was to quantify the challenges of these teachers as they use ICT in their classes at both division and regional levels. Specifically, the quantification of teachers' challenges means that this study will identify the common factors (latent variables) from a "large amount of data in individual variables and coalesce it into related groupings so that more general trends in the data can be explored" (Emerson, 2017, p. 302).

Exploratory Factor Analysis

I decided to use exploratory factor analysis (EFA) based on my research design and the nature of my data. The analysis involves common factor modeling that seeks to establish correlations among the set of latent variables similar to (Fabrigar, Wegener, Maccallum, & Strahan, 1999) confirmatory factor analysis.

The current study has a new survey instrument. The very first goal of this instrument is to explore the existing factors surrounding the experiences of science teachers as they use ICT. This constitutes the first grounds for using EFA. The EFA has no *a priori* number of common factors, since the number of common factors is based on the generated data of the study (Fabrigar et al., 1999). In EFA and in this study, *a priori* is something I thought of through "reasoning or deduction rather than through observation or data" (Emerson, 2017, p. 302). By contrast, researchers deciding to use CFA have to specify a definite number of factors together with the pattern of factor loadings extracted from the data. In EFA, the latent variables are "analyzed together, and items sharing a substantial amount of variance are collapsed into a factor" (Knekta et al., 2019, p. 7). In a CFA, the "shared variance among items that are *prespecified* to measure the same underlying construct is extracted" (p. 7, emphasis in original). In EFA, as stated above, no *a priori* number of common factors is required; the process itself specifies the relationships, whereas in CFA the common factors are initially identified by the researcher.

Second, based on Knekta et al. (2019), I used EFA since I do not have robust empirical grounds to precisely determine what "common factors exist or what specific measured variables these common factors are likely to influence" (p. 277) in my data, whereas CFA requires that there must be an existing "sufficient theoretical and empirical basis" (p. 277). The precise identification of common factors in CFA is appropriate in testing of identified hypotheses from a hypothesized or theoretical model extracted from the data (Finch & West, 1997, Knekta et al., 2019) and researchers using CFA do not depend on the *a priori* nature of data. The circumstance of having a limited "theoretical and empirical basis" for identifying common factors is due to the fact that my questionnaire is in its early stages of development. Thus, it is more appropriately treated with EFA (Knekta et al., 2019) since the use of CFA presupposes that a researcher is "using a preexisting survey that has established structure" (p. 7).

Lastly, even if EFA and CFA are often used together in a way that EFA offers grounds to define a CFA model (Fabrigar et al., 1999) and EFA results can "ideally" be confirmed with a CFA (Knekta et al., 2019), the confirmation should never be done using the same sample used for the EFA. The reason for this is that the subsequent CFA result will just be a repetition of "many of the relationships that were established through the EFA" (Knekta et al., 2019, p. 8). The desirable way of computing CFA is from an independent sample, ideally (if the study has a larger sample size) splitting the sample size into two independent groups, one for the EFA and the other for the CFA (Fabrigar, et al., 1999; Knekta, et al., 2019). Taking into account this issue of sample size, I opted solely for the EFA.

In regards to the appropriateness of sample size, researchers generally agree that larger sizes enhance the degree of approximation and statistical range (Gagne & Hancook, 2006). However, sample size depends on several considerations such as the number of factors, size of factor loadings, correlation between factors, etc. (Gange & Hancook, 2006; Wolf et al., 2013).

Assessing a desirable sample size also goes along with consideration of the properties of measured variables like communality. Communality refers to the degree to which an item correlates with all other items from the data (Communality, 2019). In this study, my sample size is 141. This size comfortably fits the EFA ,where N=50 is considered as a “reasonable absolute value” (de Winter, Dodou, & Wieringa, 2009, p. 147). This size also falls under Fabrigar et al.’s (1999) specifications. For Fabrigar et al. (1999), communalities equal to or greater than 0.70 and having four to five variables for each factor would be adequate for a sample size of 100 or better. However, based on Leandre et al.’s (2012) specification (where Fabrigar and Wegener from Fabrigar et al., 1999 are co-authors), my sample size is a quarter less than suggested—at least 200 sample size for communalities of 0.40-0.70 and at least three items for each factor. Many more authors and researchers suggest minimum sample sizes from 100-250 (Guilford, 1954; Catell, 1978; Gorsuch, 1983). Others recommend determining the ratio of sample size to the number of variables (Hogarty et al., 2005), yet final “decisions about the quality of factor solution depended upon which criteria were examined” (p. 202).

With the three reasons cited above for choosing the EFA over CFA and doing the EFA alone, the next consideration is to test the suitability of my data for EFA structure detection (Communalities, 2019). The two tests for data suitability I used included the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett’s test of sphericity (KMO, 2019). The KMO detects the proportion of variance in my data’s latent variables; KMO values that are greater than 0.50 and close to 1.0 show that EFA is desirable for my data. Bartlett’s test of sphericity, on the other hand, is an identity matrix that suggests whether my latent variables are suitable or not for EFA. Computed values of 0.05 or less signify that EFA is suitable for my data (KMO, 2019).

After resolving the use of EFA over CFA, outlining the fit of my sample size for EFA, and describing the test of suitability that will be used for my data, the next steps were deciding the number of factors to extract for EFA, performing factor extraction, and choosing factor rotation (Fabrigar et al., 1999; Knekta et al., 2019). As recommended by experts (Gorsuch, 1983; Zwick & Velicer, 1986; Velicer, Eaton, & Fava, 2000; Hayton, Allen, & Scarpello, 2004), I used multiple approaches to determine the number of factors. This included the following: Velicer's (1976) Minimum Average Partial (MAP) Test, Horn's (1965) Parallel Analysis, Cattell's (1966) Scree Test, and Maximum Likelihood and Principal Axis Factoring. Courtney (2013) further supported the idea of using multiple techniques in the determination of the number of factors, since choosing the appropriate number of factors "has a direct effect on results and subsequent theory development" (p. 1).

Once all the considerations mentioned above were factored in, the very last step for the EFA is the interpretation and reporting of factors (Kenkta et al., 2019). The reporting of the factors will be discussed in the next chapter.

3.3.5.2 Qualitative Data Analysis: Thematic Analysis

The qualitative data in this study included one-on-one interviews, focus group interviews, written observations and reflections during science video-creation workshop, memos, field notes, and documents from DICT and DepEd. The qualitative analysis for these data focused on the types and meanings of the challenges (phenomena) of science teachers as they used ICT in their classes rather than quantifying them (Denzin & Lincoln, 2000; Patton, 2002). Qualitative data were contextualized using Talmy's (2010) qualitative interview framework while being subjected to thematic analysis. Talmy (2010) conceptualizes research interviews as both "research instruments" and as a "social practice" (p. 132). As a research instrument, he argues parallel to Duff (2015) that interviews are assumed to serve as a resource for finding out "truths, facts, experience, beliefs, attitudes, and/or feelings of respondents" (p. 131). However, according to Talmy (2000), if interviews are viewed as social practice (his own view), more than establishing "factual" data for analysis, researchers are "problematizing the assumptions that constitute the research instrument perspective, and treating interviews *themselves* as topics for investigations" (p. 131, emphasis in original). From his conceptualization, I chose three elements of interviews: data, voice, and analytic approaches. Each element was interpreted as a research instrument and a social practice, respectively. This conceptualization was chosen because it was based on a series of research projects that used interviews in case study, ethnography, and qualitative-based study paradigms. Although the conceptualization was in the context of applied linguistics, I view my qualitative data as transcripts of meanings created by and through me and my research participants. The three elements I picked align with my choice. The first interview element is data. The interview transcripts as "data" are not only "reports" shared by the interviewees but also "accounts" co-constructed by both the interviewees and interviewer. The second element is voice. As with the first element, interviews "give voice" not only to the interviewees but also to the interviewer. The voice is "heard" as a co-construction of both voices. The third element is the analytic approach. The themes extracted from the analysis of interview transcripts do not merely "speak for themselves" as many interview analyses and reports would present; rather, themes are viewed as a co-construction of knowledge between interviewer and interviewees. As co-constructed knowledge, there are research values attached to them while they are subjected to thematic analysis.

Specific to observation and reflection data from science video-creation workshops, I used Taber's (2005) "Teacher-as-learning-doctor" and van Es and Sherin's (2002) "Learning to Notice" frameworks. The metaphor of "teacher-as-learning-doctor" (Taber, 2005) presupposes that teachers are acting and learning like medical doctors as they explore "diagnosis, prevention, and treatment of learning 'bugs'" (p. 219). This method of exploring involves the "typology of learning impediments," a framework that guides teachers as they examine possible reasons why students failed to develop an understanding of scientific concepts as outlined in teachers' lesson plans. In the workshops, I use this analogy as a "mentoring the mentors approach" to detect aspects of teachers' TPACK and FoK integration that might implicitly and explicitly indicate the (1) challenges they faced in using ICT and (2) administrative support and nature of professional development that they have in their respective schools. To help me "detect," I employ van Es and Sherin's (2002) "Learning to Notice" framework. In the context of van Es and Sherin's (2002) study, mathematics teachers were watching a video of a teacher doing a math lesson with students. Using the framework, the teachers who were watching the video were encouraged to identify specific teaching aspects that arose in the video and relate them to the wider concept or bigger ideas of teaching and learning processes. The key idea in this framework is to focus on a specific or distinct aspect or event in the teaching, since teachers could not conceivably capture all the things they are observing at a given time. In the current study, this framework is translated to instances like paying attention to a specific science concept teacher-participants are introducing in their video that might be a potential learning impediment (Taber, 2005). It pertains also to some specific skills in video editing that might connect to the nature of professional development science teachers have in their schools.

Thematic Analysis

Thematic analysis is one of the most popular methods of data analysis (Clarke & Braun, 2013) and the most fundamental approach to qualitative data analysis (Clarke & Braun, 2006). It is a method for "identifying themes and patterns of meaning across a data set in relation to a research question" (Braun & Clarke, 2013, p. 175). It is also a "process of analyzing data according to commonalities, relationships, and differences across a data set" (Gibson & Brown, 2009, p. 127). The process of looking and naming themes across quantitative and qualitative data sets in this study is viewed through the lenses of TPACK and FoK. Below is the sequence of steps I followed in conducting a thematic analysis as suggested by Clarke & Braun (2013):

(1). Transcribing and identifying items of interest. All audio interviews were recorded using a digital Sony model and backed up with the iPhone 6 iTalk recording app. These interviews were transcribed, member checked, and stored in NVivo. Other qualitative data (written observations and reflections made during science video-creation workshop, memos, and field notes) were also uploaded in NVivo. Through this Computer-Assisted Qualitative Data Analysis Software (CAQDAS), I organized my data and transcripts to generate a visual focus, systematize salient features, and identify items of interest related to science teachers' challenges surrounding TPACK and FoK as they use ICT in their classes.

(2). Coding and creating themes. I coded interview transcripts, observations, and reflections from the science video-creation workshops separately, aided by my field notes and memos. To code is to "break down and understand a text and to attach and develop categories and put them into an order in the course of time" (Flick, 2002, p. 178). I followed Corbin & Strauss's (2008) open-axial-selective coding, which is the analytic approach that best matched the exploratory nature of this study in identifying initial themes. The generated initial themes were condensed (axial coding) and core codes were finalized (selective coding).

(3). Reviewing themes and naming their existing relationships. This stage is practically the equivalent of going back to the open-axial-selective coding approach in step number two and then creating a storyline to establish the emerging relationships among themes.

3.4 Triangulation: Merging Quantitative and Qualitative Analysis

Triangulation is a process of defining the unknown position of a 3rd object based on the known positions of two objects as applied in military operations, navigation, and surveying (Webb et al., 1966). Employed in social sciences, it is a process where researchers look for the converging point among multiple sources of data to form themes (Creswell & Miller, 2000). Combining multiple data from both quantitative and qualitative analysis can increase rigor and trustworthiness of the findings (Leech & Onwuegbuzie, 2007) and provide breadth and depth to the themes (Gay et al., 2006), though not all convergence of data provides consistency and coherence in the findings (Mathison, 1988). In this study, triangulation was done by comparing the themes generated from both quantitative and qualitative analysis. The process of comparing themes resulted in the emergence of new and overarching themes. These themes as research findings are used for reporting.

3.5 Ethical Considerations in Research Design

In this section, I outline the ethics procedures of this study as part of my data collection procedures. My ethics application was successfully approved by the UBC Behavioural Research

Ethics Board (BREB) (Appendix D) as the UBC-internal approver and the DepEd School Division Superintendent and DepEd Region VI (Appendix E) as external approvers. The Permit Letter to Conduct a Study approved by the external bodies was cascaded to the region's science supervisor head and all the School Division Superintendents in Region VI. In return, all the School Division Superintendents relayed the letter to all junior high school principals and science department heads until it reached the attention of junior high school science teachers.

3.5.1 Recruitment

Due to limited logistics and resources, the public junior high school science teachers in the DepEd Division of Bago City were chosen as the main focus of this study rather than the whole Region VI. They were invited (Appendix F) to complete the online questionnaire, join the one-on-one interviews and focus group discussions, and attend science video-creation workshops after agreeing on all procedures and conditions as stipulated in the "Consent Letter" (Appendix G). Teachers coming from the different school divisions in Region VI were primarily invited to complete the online questionnaire with the purpose of generating region-wide level trends and perspectives. Teachers who signed up for the one-on-one interviews were contacted via email addresses they provided in the last part of the questionnaire.

There were 39 junior high school science teachers coming from eight of the nine schools in the School Division of Bago City who consented and completed the online questionnaire. However, due to conflicting administrative functions and commitments, not all of them were able to join the focus group discussions, one-on-one interviews, or science video-creation workshops. For reports and future publications, a pseudonym was assigned to each teacher and their data to maintain their confidentiality and preserve privacy. All the data were kept on an encrypted password-protected computer and physical documents were kept in locked file storage at UBC.

3.5.2 The Impacts of Researcher's Identities

In this study, particularly during my fieldwork, I considered myself not only both as an insider and outsider but as occupying a space between the teachers and their community as well. Social scientists and researchers in action research have rigorously studied the critical impacts of a researcher whose roles and identities overlap. Often, the researcher's role is described as either an "Outsider" or "Insider" (Kerstetter, 2012). An outsider is someone who is neutral and objective and does not belong to the research group, while an insider has shared experiences and engagements with members of the research team. However, Corbin Dwyer and Buckle (2009) noted that the researcher's cultural background, relationships to research participants, etc. also influence his or her status relative to a research group over time. This growing status creates the "space between" the outsider/insider's identities. Thus, the researcher's role evolves as a combination of an outsider/insider/space between.

As an insider, I was a student leader and one of the top-performing students until my graduating year at Ramon Torres National High School. I was a practicum student teacher for three months under one of the physics teachers in this school, who was also a research participant in this study. Three of the current high school principals were my former high school teachers. One of them was my former physics teacher, while another was my Student Government Organization adviser. One principal was a former scoutmaster during my time as a high school boy scout. Some of the science teachers I interviewed were the brother, sister or relative of my high school classmates and friends. Moreover, like most of the teachers in this division school, I was also a student trained to be a teacher by a state-funded teacher education college. As an outsider, I arrived in this school as a physics and science teacher who taught in a privileged exclusive Catholic school for girls in an urban private high school in the Philippines. It was a school detached from the realities and environments of rural public high schools. I am also a university researcher, a position that connotes prestige among public high school teachers. These teachers regarded university researchers like me as individuals with expertise. However, public school teachers are also often skeptical of researchers like me, believing we are only interested in mining their data and artefacts and converting them into research publications.

On the other hand, as a result of my daily contact with most of the science teachers, especially during lunch, recess, etc., I felt that I developed some sense of community with them—my third identity as "space between." I joined with them when they visited the wake of a former colleague. I ate with them during break time. I was an observer during their department meeting. I went home with them riding on the same tricycle and bus. Some of them were brothers or sisters of my friends and cohorts in the high school. I felt that I was part of their science department community.

In order to balance these overlapping identities that I project to my research participants, I consciously tried to maintain a strong impartiality and relationship of trust towards all of them. This was an endeavor to maintain the robustness, reliability, and validity of my data gathering and the whole procedure of critical analysis and triangulation (Finlay, 2012). This was also my attempt to minimize the Hawthorne effect (Franz, 2018); that is, limiting the potential biases where science teachers are displaying responses they perceive as expected, favorable, and satisfactory responses for my research. Finally, as a variant of the Hawthorne effect, I devoted extra attention to how I used and emphasized the recording tools I utilized to record and observe my participants. When science teachers are aware that their speech, conversations, and actions are being recorded for special purposes, e.g., international research, they might deviate from their casual ways when they are left by themselves. Such deviation would generate data that might affect the content and quality of research analysis of this study. Gordon (2013) calls this the "Observer's Paradox," cautioning researchers that any phenomenon being observed is undermined by the presence of the observer and the tools being used to observe the phenomenon.

3.5.3 Data Collection Timeline

I arrived at my field site on Nov. 28, 2018 and completed data gathering on Jan. 28, 2019. The online questionnaire was first distributed to the main participants, i.e., the teachers in the Division of Bago City, on Dec. 5, 2018. The interviews focus group discussions, and science video-creation workshops followed until January 15, 2019. Teachers from other school divisions in the region were invited to complete the survey from June 1 to July 30, 2019.

3.6 Summary

This chapter delved into detailing the methodology and methods of my study. I used a descriptive case study approach centered on mixed methods to find answers to my research questions. I discussed the quantitative and qualitative data and process of analysis under the five subheadings of descriptive case study research design: (1) research questions, (2) study propositions, (3) units of analysis, (4) data collection procedures, and (5) data analysis techniques.

The quantitative method used an online survey questionnaire. It was deployed to generate division- and region-wide perspectives of the challenges faced by select public junior high school science teachers in the Division of Bago City, Negros Occidental, Philippines as they integrate ICT in their classes. The qualitative method gathered data in the form of one-on-one interviews, focus groups, observation and reflection notes from workshops, and field and memo notes. These data were analyzed to describe trends and patterns of challenges at the division level. Table 8 summarizes both methods used to address the research questions of this study.

Research Questions and the Summary of Methods Used		
Research Questions	Quantitative Method	Qualitative Method
1) What are the experiences, including key challenges by rural junior high school science teachers, during integration of ICT in their science teaching within Philippine's public high schools? 2) In what ways are the encountered experiences relate to (a) curriculum and pedagogy (b) professional development (PD); and 3) How are the experiences, especially the key challenges (a) transformed into enablers of dissemination of good practices and (b) in turn inform both institutional and Government level policy frameworks?	Online Questionnaire: *Validity and reliability tests *Descriptive Statistics *Exploratory Factor Analysis	*One-on-one semi-structured interviews *Focus group interviews *Science video-creation workshops *Thematic Analysis using TPACK & FoK frameworks *Additional frameworks used for analysis: a) Talmy's (2010) Interview framework b) Taber's (2005) Teacher-as-learning-doctor framework c) Van Es & Sherin's (2002) Learning to Notice

Table 8: Research Questions and Summary of Methods Used

Chapter 4: Quantitative Data Analyses

This chapter presents the quantitative analyses of the questionnaire data. The analyses cover the discussion of the general profile of public junior high school science teachers as research participants and the emerging themes related to the challenges they faced as they used ICT. Teachers' general profiles are described using descriptive statistics and the emerging themes are extracted from the EFA.

4.1 Quantitative Data Analysis: The Questionnaire

The 36-item questionnaire (Tables 9-10, also in the Appendix A) adapted from the original 40-item questionnaire and validated was used to provide school division and regional level perspectives on the experiences of public junior high school science teachers as they integrate ICT in their classes. The data from the teachers in the Division of Bago City were gathered in Dec. 2018, while data from the rest of the teachers in DepEd Region VI were gathered in June 2019. The questionnaire was cascaded to the teachers through mailing lists managed by the regional science supervisor. Participation was voluntary, and so no specific sampling procedures were observed. The questionnaire contained 15 open-ended and multiple-choice questions and 21 Likert-type agree-disagree items on a five-point scale for a total of 36 questions. The 21 Likert-type items (Table 9) were used for the EFA and the 15 items (combination of open-ended and multiple-choice type) (Table 10) were reported as tally and percentage.

Challenges

Strongly Agree Agree Neutral Disagree Strongly disagree

Q1. I am convinced that integrating technology in science teaching improves teacher-student interaction.

Q2. I am convinced that integrating technology in science teaching improves students' understanding of science.

Q3. I am convinced that integrating technology in science teaching improves teacher confidence in the use of technology.

Q4. I am convinced that integrating technology in science teaching reduces digital divide between teacher and student.

Questions #5-#7 apply to ICT initiatives implemented in any levels from two years ago or earlier

Q5. Were there useful/relevant ICT (information and communications technology) projects or initiatives from your Division level implemented in science in your school?

Q6. Were there useful/relevant ICT (information and communications technology) projects or initiatives from your Region implemented in science in your school?

Q7. Were there useful/relevant ICT (information and communications technology) projects or initiatives from the National level implemented in science in your school?

Q8. My school's division provided relevant technology for science teaching four weeks ago.

Q9. My school's division provided relevant technology for science teaching last year.

Q10. My school's division provided relevant technology for science teaching two years ago.

Q11. My school's division provided relevant and appropriate technology training for science teachers two weeks ago.

Q12. My school's division provided relevant and appropriate technology training for science teachers last year.

Q13. My school's division provided relevant and appropriate technology training for science teachers two years ago.

Q14. I am convinced that students learn and understand more about science when ideas, concepts related to the community are integrated with technology.

Q15. I am convinced that students learn and understand more about science when beliefs, and practices related to the community are integrated with technology.

Q16. I am confident that I have the needed knowledge of my science contents in order for me to choose appropriate technology to use in my science class four weeks ago.

Q17. I am confident that I have the needed knowledge of my science contents in order for me to choose appropriate technology to use in my science class last year.

Q18. I am confident that I have the needed knowledge of different science teaching strategies in relation to any science content four weeks ago.

Q19. I am confident that I have the needed knowledge of different science teaching strategies in relation to any science content last year.

Q20. I am confident that I have the needed knowledge of different science teaching strategies in relation to any science content along with the skills in choosing appropriate technology for my science class four weeks ago.

Q21. I am confident that I have the needed knowledge of different science teaching strategies in relation to any science content along with the skills in choosing appropriate technology for my science class last year.

Table 9: 21 Likert-type Items from the Questionnaire

Demographic (D) Profiles

D1. I belong to the Schools Division of _____.

D2. I am teaching _____ (subject/s) (tick all that apply) for (please write the number of years in the box) _____.
General Science Earth Science Biology Chemistry Physics

D3. My bachelor's degree is in _____.
Education Others _____.

D4. My master's degree is in _____.
Education Others _____.

D5. I have not graduated yet but have earned units leading to master's degree in _____.

D6. Someone defined technology as "crossing the river without getting my feet wet". Others described technology by citing the efficiency of MS Excel in computing for students' grades. As a science teacher, how do you define technology?

D7. Do you have Internet connection provided by the school for science class use?
Yes No. I am using my personal data subscription Others/comments.

D8. Do you use a laptop in your science class?
Yes No

D9. Use of laptop in science class: Which one did you do most frequently for the last four weeks?
To show a video about a science concept, through online link or power point
To show diagram, pictures, or illustration of science concept
To send emails, announcement to students
For online quiz, games, puzzles
For assignments, short quiz
Others

D10. Use of laptop in science class? Which one did you do least frequently for the last four weeks?
To show a video about a science concept, through online link or power point
To show diagram, pictures, or illustration of science concept
To send emails, announcement to students
For online quiz, games, puzzles
For assignments, short quiz
Others

D11. What specific trainings on the use of technology that you think are more appropriate in your science class now? Multiple answers allowed.
Bridging teaching strategies using online resources and students' local context
Connecting multimedia – TV monitor, projector, computer, printer
Creating multimedia presentations – power point, video
Choosing the best science teaching resources online
Developing multimedia presentation skills
Others

D12. What difficulties have you faced when you use any technology in your science class for the last four weeks? Multiple answers allowed.
Not confident enough if I have used, demonstrated, and explained such technology correctly
No available staff, colleague to assist in cases such technology malfunctions
Not convinced if such technology were appropriate for a given science topic
Not completely functional or working, defective, old
Limited availability, not enough for the class
Limited knowledge to troubleshoot
No or slow Internet connection

D13. What were the ideas, concepts, beliefs, and practices related to the community, students, students' families, students' history and culture, etc. that you have used in your science class inside and outside the classroom to

help students understand or appreciate science concepts and theories for the last two grading periods? Multiple answers allowed. Parents', grandparents' and elder people's experience and wisdom Religious symbols, beliefs and practices – fiesta, festivities, etc. Professions, jobs, hobbies within the barangay/community Lands, rivers, seas, mountains, hills, landscapes, etc. Local and indigenous music, news, sports, arts Local agriculture, fishing, business practices Gender, marriage, religion, laws
D14. What difficulties have you faced when you use any of the ideas, concepts, beliefs, and practices related to the community, students, students' families, students' history and culture, etc. in your science class for the last two grading periods? Multiple answers allowed. Not confident enough if I have used, demonstrated, explained such ideas and concepts correctly Not convinced if such ideas and concepts made students learn or understand science Not confident enough if such ideas and concepts were relevant and proper to use Not motivated to use such ideas and concepts Not enough time for one period and class
D15. Are you interested to be contacted via Messenger, WhatsApp, or Skype if I have some questions or clarifications about your answers in this survey? You will receive 300 pesos as a professional honorarium for 45-60 minutes of interview.

Table 10: 15 Open-ended and Multiple Choice Items from the Questionnaire

4.1.1 Descriptive Statistics

This section describes the profile of public junior high school science teachers who voluntarily completed the questionnaire. The analysis was based on the answers to all 14 questions under the Demographic Profile section of the questionnaire.

4.1.1.1 Distribution of Science Teachers

There were 141 science teachers who completed the questionnaire. They were from 15 of the 20 school divisions comprising DepEd Region VI, Western Visayas (Figure 7). Each division was marked by a star. The teachers from the Division of Bago City, marked below by a circle, were the primary focus of this study and had the highest participation rate at 39. They were followed by the Divisions of Cadiz City at 25 and Iloilo Province at 21, respectively (Figure 8).

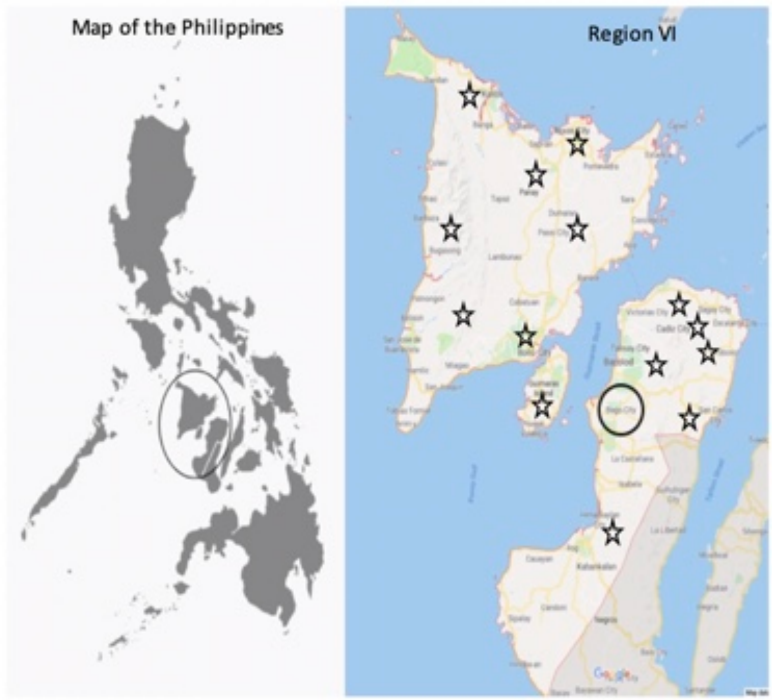


Figure 7: Locations of Teacher-Participants in Region VI (adapted from Google Maps, 2019)

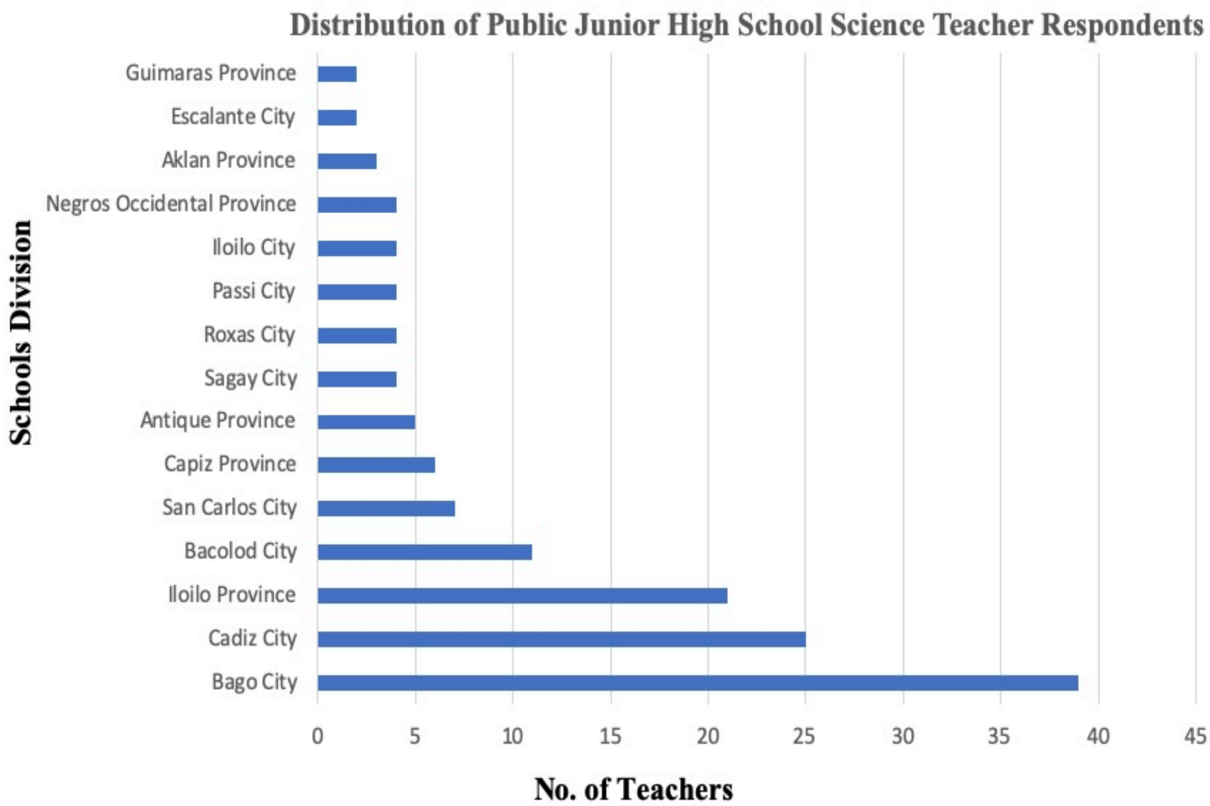


Figure 8: Distribution of Teacher-Participants in Region VI

4.1.1.2 Subjects Taught and Number of Years

In the new DepEd K-12 curriculum, junior high school science teachers teach other core science subjects (biology, chemistry, and physics) in addition to their own specialization. At any given grade level from Grade 7–10, a science teacher teaches any science subjects in a spiral progressive manner (SEAMEO, 2012). Of the 141 science teachers, 89 were teaching physics. Moreover, regardless of the subjects taught, most of the teachers were in their early years of teaching. Figure 9 shows that the overwhelming majority of teachers were in their 1st to 3rd year of teaching experience, followed by those in their 4th–6th year, and a handful in their 11th year and upward.

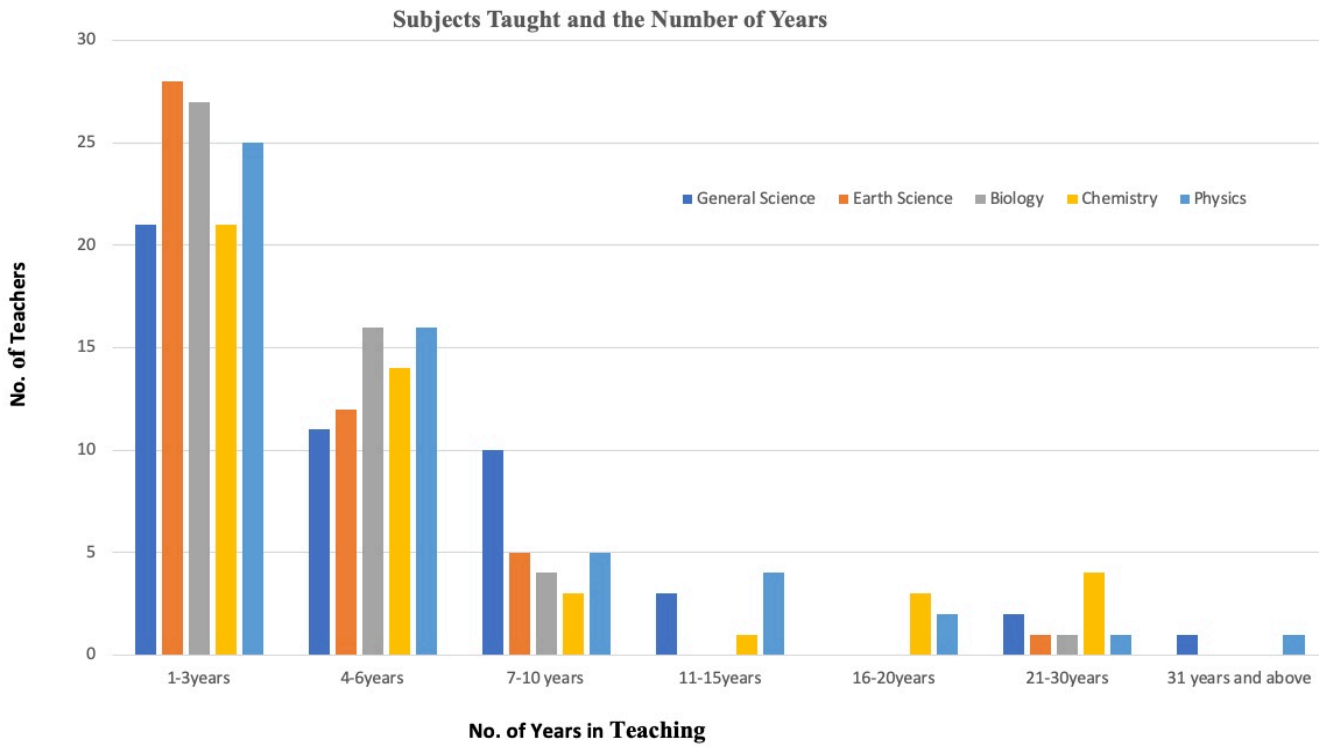


Figure 9: Subjects Taught and Years of Teaching Experience

4.1.1.3 Science Teachers' Preparation

As regards degree preparation, Figure 10A shows that nearly 80% of the 141 teachers have completed their bachelor's degree in education. As well, Figure 10B shows that more than 75% of the teachers have master's degree in education. Teachers with non-education bachelor's degrees were graduates of nursing and computer science programs. Teachers with non-education master's degrees were graduates of public administration, management, and industrial technology programs.

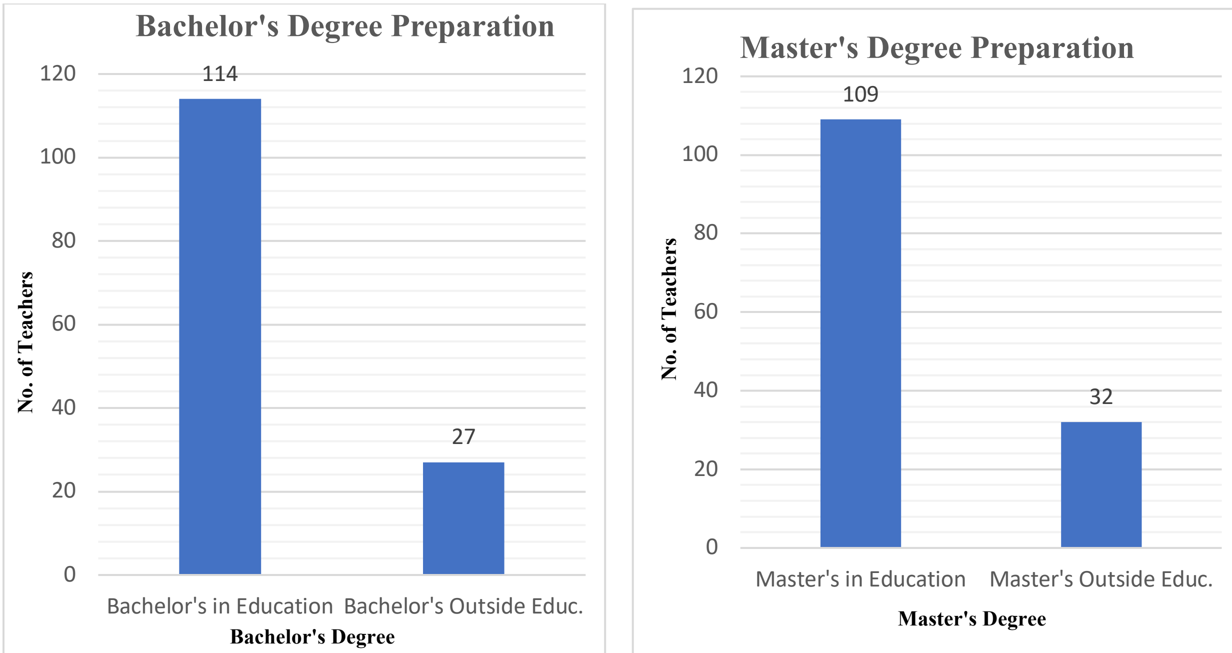


Figure 10: Bachelor's (A) and Master's (B) Degrees Holders

4.1.1.4 Internet Accessibility and Laptop Use

Based on Figure 11, around 20 teachers have Internet access provided by the school for their science classes, while almost 100 teachers accessed it through their personal data subscriptions. Other teachers had Internet access at home or in their faculty room, computer room, or specified offices.

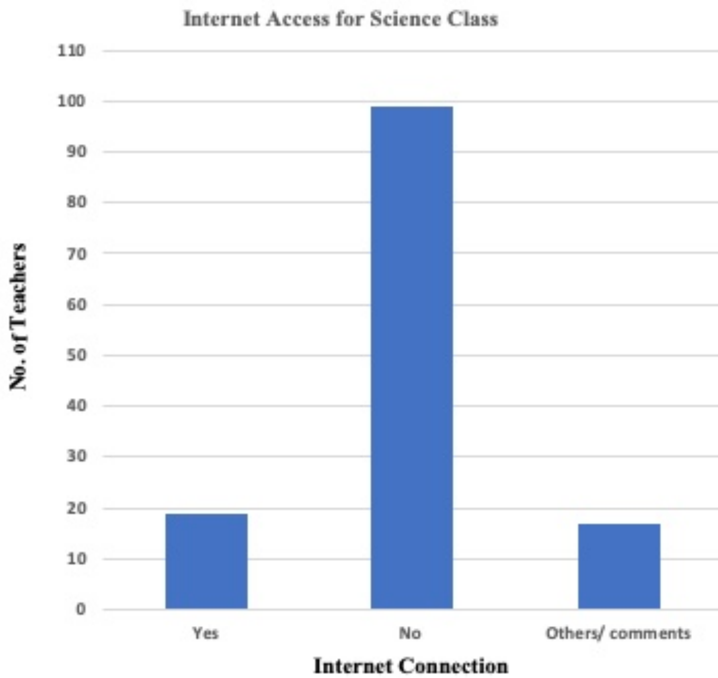


Figure 11: Internet Access for Science Class

In terms of laptop ownership, Figure 12 shows that the vast majority of teachers had their own laptops and used them in their science classes. In terms of laptop use, Figure 13 shows that the use of videos is widely observed among science teachers, followed by the use of diagrams and pictures.

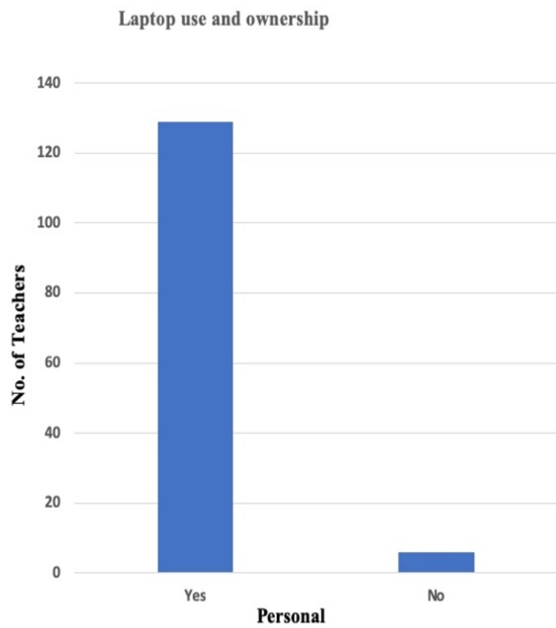


Figure 12: Laptop Ownership

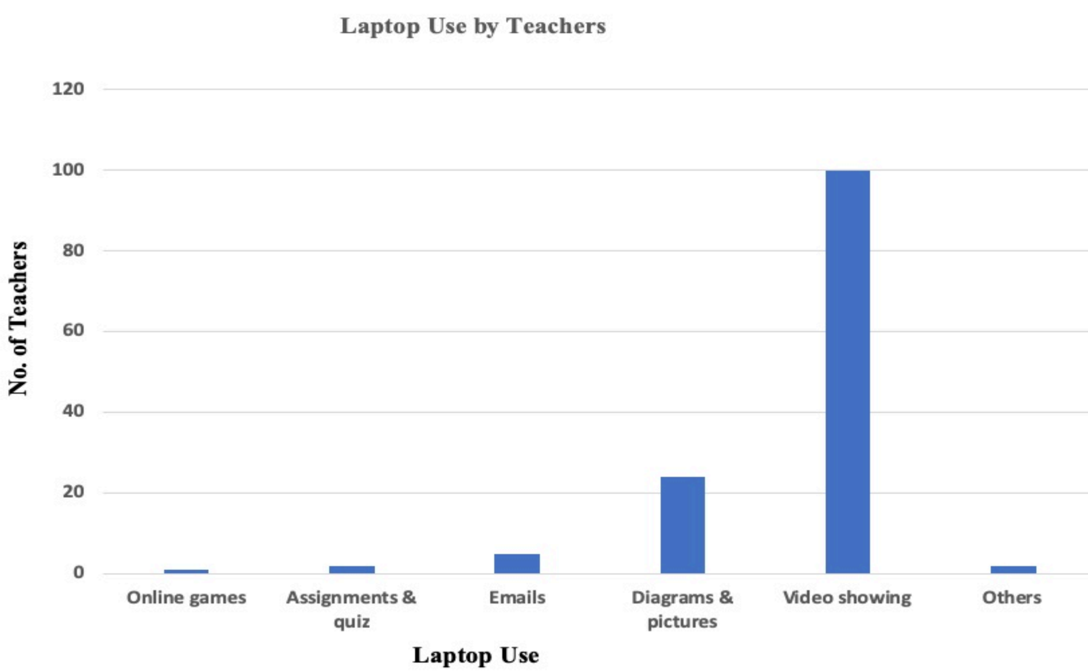


Figure 13: Laptop Use in Science Class

Meanwhile, a large number of teachers enumerated the difficulties they encountered specifically in using laptops in their classes. Their topmost challenge was that there was either a slow Internet connection or none at all. The rest of the list is shown in Figure 14.

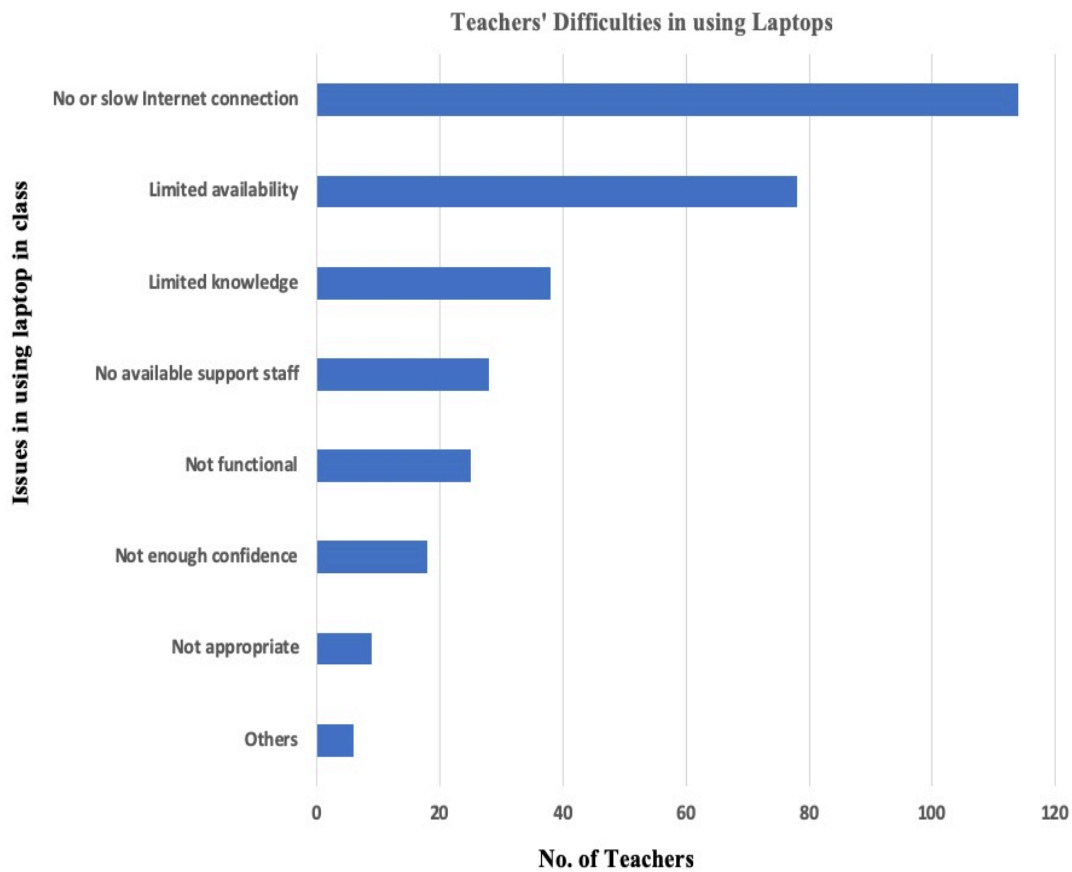


Figure 14: Difficulties When Using a Laptop

Science teachers were asked about what specific training on the use of technology would be appropriate for their science classes. The two most common suggestions by teachers were: (1) what and how teaching strategy could bridge online resources in science and students' local contexts and (2) how to create multimedia presentations like PowerPoint and video (Figure 15).

They also suggested skill building related to how to search for and choose the best science teaching resources online and develop effective multimedia presentations.

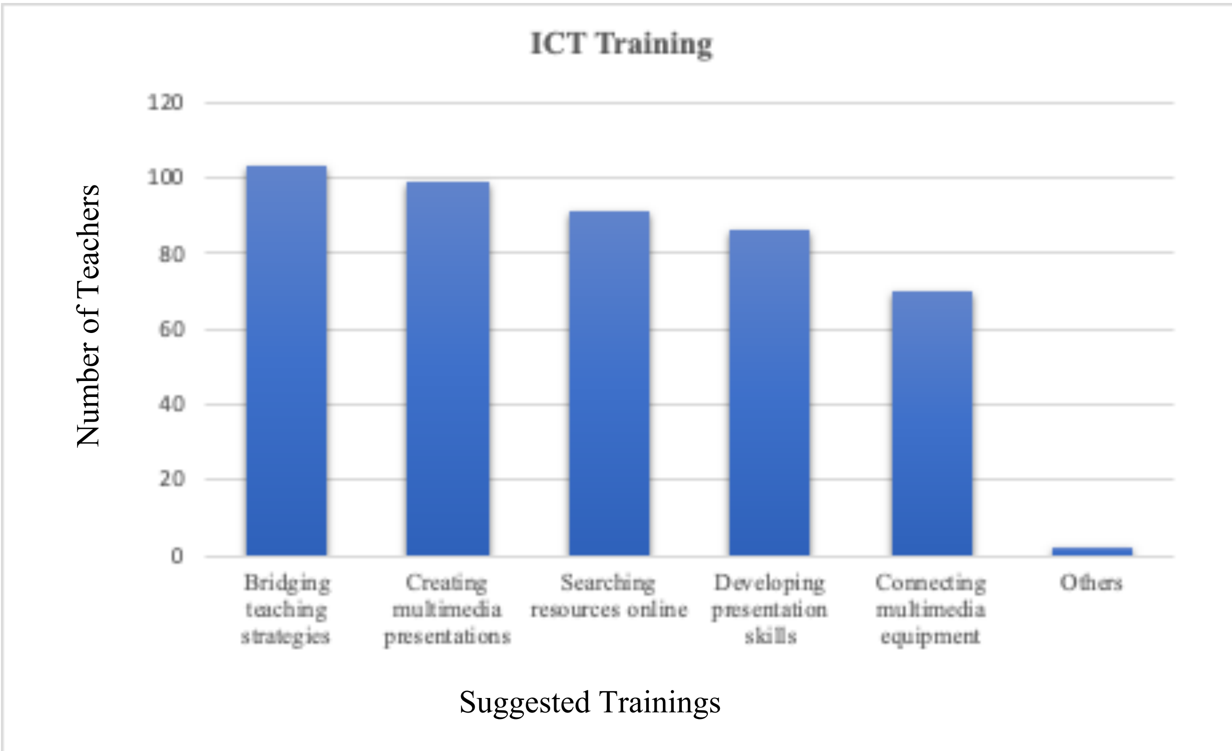


Figure 15: Suggested ICT Training

4.1.1.5 Use of Funds of Knowledge (FoK) in Science

When the science teachers were asked for the types of FoK they introduced in their science classes, local geography topped the list at 99 teachers (Figure 16). For example, in Earth and General Science, teachers used local geography to discuss earthquakes, fault lines, types of volcanoes. This was followed by local agriculture and beliefs of parents and elders in the community at 77 and 63 teachers, respectively. On the other hand, more than 100 teachers strongly cited limited time as the topmost reason for not using FoK in their science classes. A considerable number of them also cited reasons like FoK's connection and relevance to science and their own confidence and motivation (Figure 17).

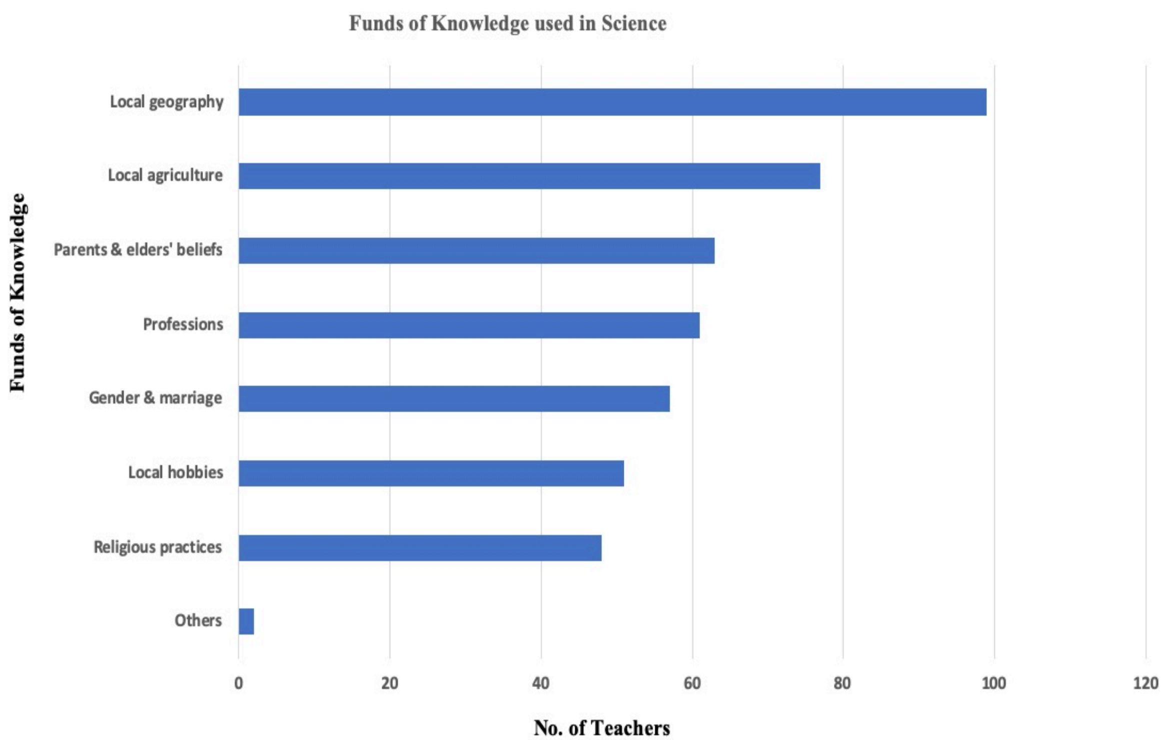


Figure 16: Funds of Knowledge Used in Science

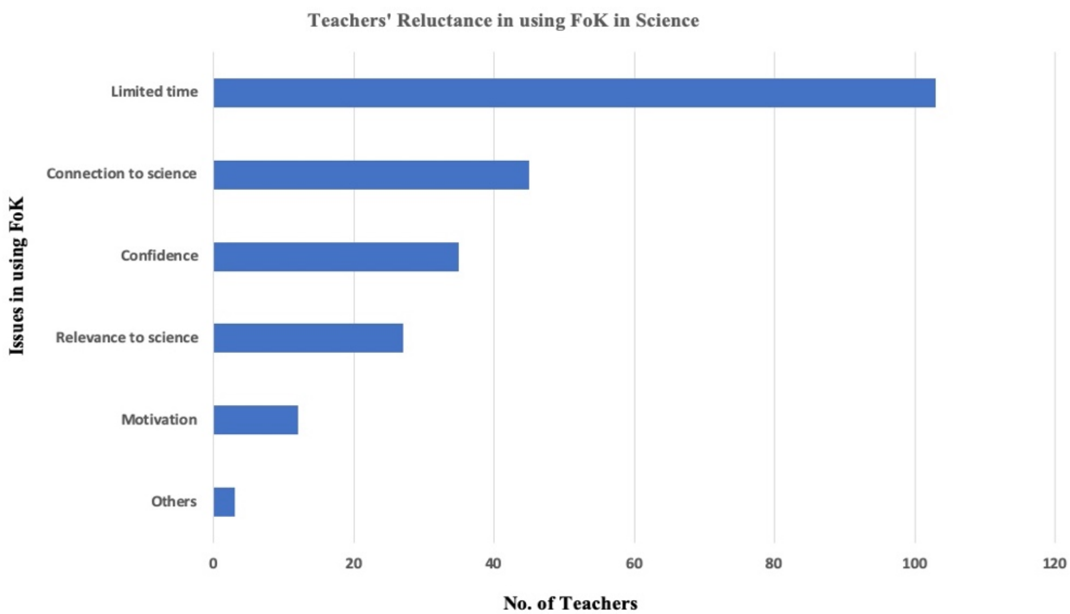


Figure 17: Reluctance in Using Funds of Knowledge Used in Science

4.1.1.6 Teachers' Views of Technology

As a general term and in relation to science teaching, technology was coded as defined by the majority of teachers as an "application" of science and knowledge (Figure 18) without any strong reference to teaching and learning. By contrast, the second most popular definition was more indicative of teachers' positive beliefs and attitudes regarding the potential of ICT to improve learning. This definition was coded as a "bridge to understanding." Examples of teachers' definitions include a "modern and easy step in teaching," "makes a big difference in the teaching-learning process," an "aid for better scientific-inquiry," helping to "better explain the abstract concepts," "partner of teachers in education," etc. The next three popular definitions coded as "tool," "convenience," and "efficiency" further support teachers' optimistic outlook on the educational value of ICT.

Name	Files	References
Alter ego	1	1
Competence	1	1
Easy access	1	1
Solution	1	1
Catalyst	1	2
Utilization	1	2
Innovation	1	3
Miracle and curse	1	3
Technique	1	3
Product	1	6
Efficiency	1	13
Convenience	1	14
Tool	1	22
Bridge to understanding	1	39
Application	1	47

Figure 18: Teachers' Views of Technology

4.1.2 Exploratory Factor Analysis (EFA): Emergent Themes

EFA is a well-known technique (Cudeck & MacCallum, 2007) in behavioral science research to display how each factor in the study relates to the others. In this study, it was used to explore the existing factors (latent variables) surrounding the challenges of science teachers as they use ICT. The challenges faced by the science teachers were extracted into emerging themes by identifying and determining the common factors (latent variables) from a "large amount of data in individual variables and coalesce[ing] it into related groupings so that more general trends in the data can be explored" (Emerson, 2017, p. 302). Moreover, employing EFA to studies which are in their early stages of development, like this current study, is "particularly appropriate for scale development where little theoretical basis exists for specifying the number and patterns of common factors" (Gordon & Courtney, 2013, p. 1). Statisticians and researchers alike understand that it is highly essential to obtain an appropriate number of factors. Thus, the manner by which factors are extracted and retained will have absolute consequences for attempts to introduce and develop new theoretical propositions (Gordon & Courtney, 2013).

In this study, multiple approaches were used to determine and retain the number of factors as recommended by experts (Gorsuch, 1983; Zwick & Velicer, 1986; Velicer, Eaton, & Fava, 2000; Hayton, Allen, & Scarpello, 2004). All computations except those specified were done using SPSS version 23. Each approach was described and the corresponding result was provided. Then, the final number of factors was determined from the combination of individual results. Afterward, the factors retained were explained conceptually and analytically while the research questions were kept in mind. However, even if the final number of factors retained through EFA is an empirical and unique product of "mechanics and mathematics of the method" (Kieffer, 1999, p. 77), "It is we who create meanings for things in deciding how they are to be used" (Mulaik, 1987, p. 301). Furthermore, Thompson and Daniel (1996) remind us that "analytic results can inform the definitions we wish to create, even though we remain responsible for our elaborations and may even wish to retain the definitions that have not yet been empirically supported or that limited empirical evidence may even contradict" (p. 202).

4.1.2.1 Tests for Data Suitability: KMO and Bartlett's Test of Sphericity

These tests detect the structure of variance and eligibility of the data for EFA (KMO, 2019). These tests are computed before employing different methods to extract the number of factors from within the data of the study.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)

KMO is a proportion of shared variance among variables. High values close to 1.0 indicate higher suitability for EFA. A data with a KMO value of lower than 0.50 will not yield a useful EFA (KMO, 2019). The computed value for this study is 0.712.

Bartlett's Test of Sphericity

Bartlett's test of sphericity, on the other hand, is an identity matrix that suggests whether latent variables in the data are suitable or not for EFA. Sphericity at less than 0.05 of the significance level indicates suitability for EFA (KMO, 2019). The computed value for this study is $p<0.001$. The computed values for KMO and Bartlett's Test of Sphericity (Table 11) show that the data from this study is suitable for EFA.

<table>
<tr><th colspan="3">KMO and Bartlett's Test</th></tr>
<tr><td colspan="2">Kaiser-Meyer-Olkin Measure of Sampling Adequacy</td><td>0.712</td></tr>
<tr><td rowspan="3">Bartlett's Test of Sphericity</td><td>Approx. Chi-Square</td><td>1406.138</td></tr>
<tr><td>df</td><td>210</td></tr>
<tr><td>Sig.</td><td>.000</td></tr>
</table>

Table 11: Kaiser-Meyer-Olkin and Bartlett's Test

4.1.2.2 Multiple Methods to Extract the Number of Factors

Kaiser's Eigenvalue-greater-than-one-rule

Kaiser (1960) proposed that only factors with eigenvalues greater than one should be retained. This is a default setting in IBM SPSS for EFA. The computed eigenvalues for this data were taken from two extraction methods: Maximum Likelihood and Principal Axis Factoring.

Maximum Likelihood

This extraction method defines “a set of parameter estimates for a model that are most likely to produce the observed data” (Fabrigar & Kan, 2018, p. 6). The assumption of this method matches the nature of the data gathered in this study, since they are “a random sample drawn from some defined population and…the measured variables have a multivariate normal distribution” (Fabrigar & Kan, 2018, p. 6). Maximum Likelihood was extracted using Oblimin with the Kaiser normalization rotation method, which falls under an oblique rotation type. This kind of rotation was used with the assumption that the variables in the data correlate with one another (Henson & Robert, 2006). All extractions for the 21-item (variable) questionnaire in this study were done using oblique rotation set at 100 iterations. As seen below (Table 12), the computation resulted in six factors with eigenvalues > 1. At this preliminary stage, each factor was linked to individual Likert-type items found in Table 9. These items linked into individual factors (generating six separate factors) as they were correlated to one another. As seen in later stage, these individual Likert-type items will further converge into factors fewer than six.

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	7.292	34.726	34.726
2	3.201	15.245	49.971
3	2.037	9.702	59.673
4	1.603	7.634	67.307
5	1.264	6.020	73.327
6	1.027	4.890	78.217
7	.847	4.032	82.249
8	.733	3.490	85.739
9	.611	2.908	88.647
10	.482	2.295	90.942
11	.377	1.797	92.739
12	.358	1.707	94.445
13	.250	1.191	95.636
14	.227	1.080	96.716
15	.204	.970	97.686
16	.132	.631	98.317
17	.115	.547	98.863
18	.085	.407	99.270
19	.067	.320	99.590
20	.048	.229	99.819
21	.038	.181	100.000

Table 12: Eigenvalues Extracted Using Maximum Likelihood

Principal Axis Factoring

Principal Axis Factoring extracts common variance from sets of variables from the sets of matrix association in the data (Henson & Roberts, 2006). The extraction was done using Oblimin with the Kaiser normalization rotation method. Similar to Maximum Likelihood extraction, Principal Axis Factoring generated six factors with identical eigenvalues > 1 (Table 13).

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	7.292	34.726	34.726
2	3.201	15.245	49.971
3	2.037	9.702	59.673
4	1.603	7.634	67.307
5	1.264	6.020	73.327
6	1.027	4.890	78.217
7	.847	4.032	82.249
8	.733	3.490	85.739
9	.611	2.908	88.647
10	.482	2.295	90.942
11	.377	1.797	92.739
12	.358	1.707	94.445
13	.250	1.191	95.636
14	.227	1.080	96.716
15	.204	.970	97.686
16	.132	.631	98.317
17	.115	.547	98.863
18	.085	.407	99.270
19	.067	.320	99.590
20	.048	.229	99.819
21	.038	.181	100.000

Table 13: Eigenvalues Extracted Using Principal Axis Factoring

Cattell's Scree Test

Cattell (1966) introduced the Scree test of computed eigenvalues from a matrix of association. Eigenvalues are plotted in descending order. The plot looks like a cliff and the number of factors to be retained is done by visual inspection. All eigenvalues that link up to the last eigenvalue, which represents the significant drop in the cliff or "scree" in the graph, represent the factors to be retained.

The Scree plot generated in this study, as plotted from the identical eigenvalues for both Maximum Likelihood and Principal Axis Factoring, is shown below (Figure 19). The 6th factor in the Factor Number axis seemingly represents the scree of the graph. The 7th factor has an eigenvalue < 1 and so was not included. All the points starting from the cliff or "scree" upward were the factors retained, and there were six of them.

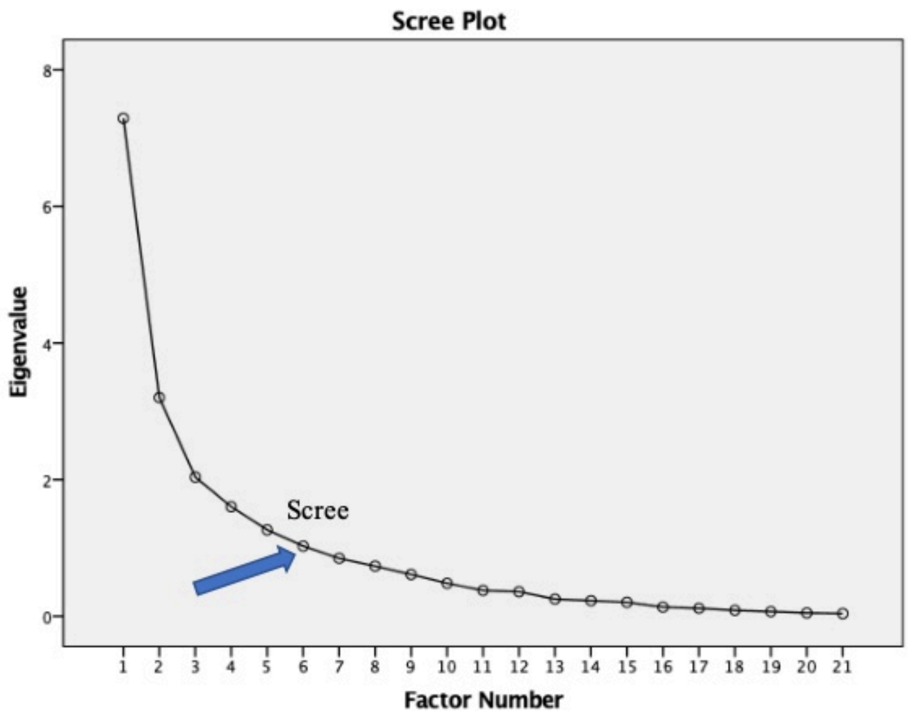


Figure 19: Scree Plot for Six Eigenvalues > 1

Velicer's Minimum Average Partial Test

Velicer's (1976) and Zwick & Velicer's (1986) Minimum Average Partial Test is a parallel analysis used to compare with Maximum Likelihood, Principal Axis Factoring and other extraction methods in order to assist in the empirical determination of the number of factors to be retained. It is "among the most accurate methods for determining the number of factors, most authors failed to use…" (Henson & Roberts, 2006, p. 407). It lowers the number of variables to smaller number of components and links them from the analysis of the matrix of association (Velicer, 1976). The computation of Velicer's Minimum Average Partial Test was done using O'Connor's (2000) syntax codes performed in SPSS version 23 with 1000 data set iterations. Based on Velicer's Minimum Average Partial Test, the smallest average squared partial correlation is 0.0532. The smallest average 4^{th} power partial correlation is 0.0086, and the number of components according to the original (1976) Minimum Average Partial Test is three. Moreover, the number of components according to the revised (2000) Velicer's Minimum Average Partial Test is also three (Table 14). Thus, three factors were retained.

Factor	Total
1	7.2924
2	3.2014
3	2.0375
4	1.6031
5	1.2642
6	1.0269
7	.8467
8	.7329
9	.6107
10	.4819
11	.3773
12	.3584
13	.2501
14	.2267
15	.2037
16	.1324
17	.1148
18	.0855
19	.0672
20	.0480
21	.0380

Table 14: Factor extraction using Velicer's Minimum Average Partial Test

Horn's Parallel Analysis

Horn's Parallel Analysis generates a large number of data matrices from randomized data parallel with the real data from some defined population (Gordon & Courtney, 2013). The matrices of factors from real data with eigenvalues > than the mean eigenvalue were generated from random data matrices. Gordon & Courtney (2013) describe Horn's PA, an alternative to eigenvalue-greater-than-one, as one of the most strongly recommended techniques (Zwick & Velicer, 1986; Fabrigar et al., 1999; Velicer, Eaton, & Fava, 2000; Hayton, Allen, & Scarpello, 2004; Henson & Roberts, 2006; Ruscio & Roche, 2012). The computation was done using

O'Connor's (2000) syntax codes performed in SPSS version 23 with 1000 data set iterations. Table 15 shows that the parallel analysis yielded three eigenvalues > 1.

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.065	22.941	22.941
2	2.015	22.388	45.328
3	1.990	22.106	67.434
4	.577	6.414	73.848
5	.521	5.790	79.638
6	.503	5.592	85.230
7	.475	5.282	90.512
8	.435	4.828	95.340
9	.419	4.660	100.000

Table 15: Factor Extraction Using Horn's Parallel Analysis

4.1.3 Summarizing EFA: Determining the Final Number of Factors

Below (Table 16) is the summary of extraction methods and the corresponding eigenvalues. Maximum Likelihood & Principal Axis Factoring generated six identical eigenvalues greater > 1. These eigenvalues represented the number of factors to be retained. Cattell's scree plot test also gave six eigenvalues greater > 1 but recommended three factors to retain. However, Horn's Parallel Analysis generated three eigenvalues > 1 and set that number as the number of factors to be retained.

	Eigenvalue : Actual Data		Parallel Analysis	
Factor	Maximum Likelihood	Principal Axis Factoring	Horn's Parallel Analysis	Velicer's Minimum Ave. Partial Test
1	7.292	7.292	2.065	7.292
2	3.201	3.201	2.015	3.201
3	2.037	2.037	1.990	2.037
4	1.603	1.603	0.577	1.603
5	1.264	1.264	0.521	1.264
6	1.027	1.027	0.503	1.027

Table 16: Summary of Extraction Methods to Determine the Number of Factors to Retain

By plotting the data from the above table using scree plot test (Figure 20), the 3rd factor from actual data was found to be the scree of the graph. There were three factors counted from the scree point and upward. These three factors closely aligned with a three-factor variable from Velicer’s Minimum Average Partial Test and Horn’s Partial Analysis. Thus, these three factors were identified as the emerging factors and were chosen for retention.

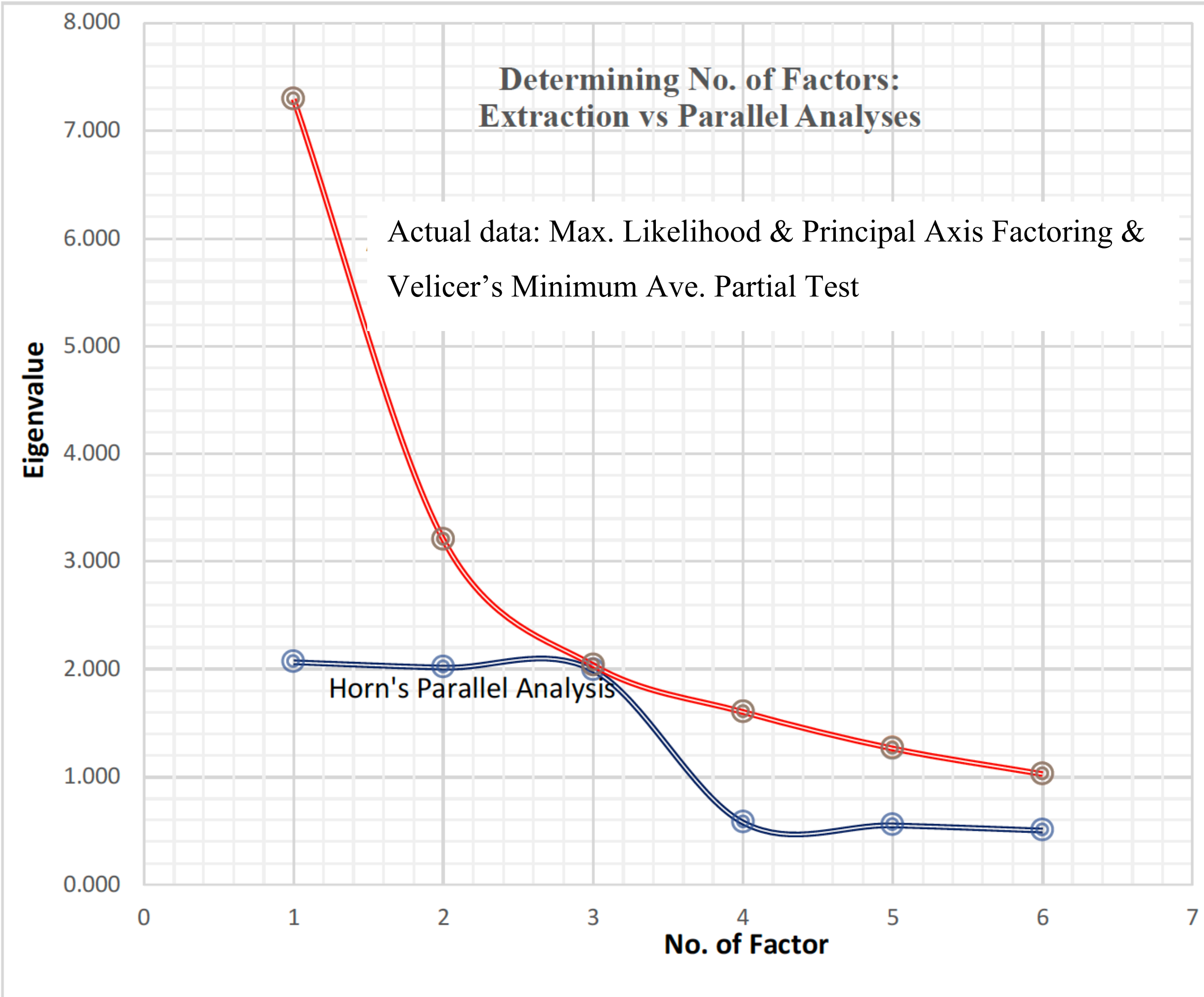


Figure 20: Scree Plot of Combined Extracted Methods

Table 17 shows pattern matrices from two- to five-factor constructs (a–d). The data from the pattern matrices were used to reproduce the common variables that interlink with each other. Particularly for Direct Oblimin, the pattern matrix provides simplification for how factor patterns form with interlinked variables (Gorsuch, 1983). Following Gorsuch (1983), the simplified and interlinked factors (variables) were more visible with a pattern matrix of the three-factor construct (Table 17b) than the rest of the matrices. Moreover, the number of variables converging in each individual factor matched with the three-factor construct in Table 17b. For example, the variables or items Q5-Q13 in the questionnaire converged together in Factor 2 under the three-factor construct (as also seen in Figure 21), whereas these items do not converge in the rest of the constructs. Likewise, the pattern matrix for the three-factor construct is similar to the rest of the constructs which have similar factor loadings greater than 0.2 degree factor loadings. This provided further confirmation for retaining the three-factor construct for EFA.

a) Pattern Matrix[a]

	Factor	
	1	2
Q1	.394	.066
Q2	.278	.180
Q3	.437	.023
Q4	.328	-.036
Q5	.140	.422
Q6	.192	.529
Q7	.169	.478
Q8	.070	.709
Q9	-.038	.850
Q10	-.251	.887
Q11	.119	.599
Q12	.143	.751
Q13	-.199	.753
Q14	.363	.286
Q15	.457	.187
Q16	.723	.082
Q17	.833	-.032
Q18	.816	-.036
Q19	.869	-.045
Q20	.793	-.072
Q21	.865	-.086

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.[a]

a. Rotation converged in 6 iterations.

b) Pattern Matrix[a]

	Factor		
	1	2	3
Q1	.048	-.019	.596
Q2	-.024	.108	.514
Q3	.159	-.035	.472
Q4	-.016	-.126	.584
Q5	.168	.434	-.015
Q6	.241	.549	-.040
Q7	.203	.491	-.018
Q8	.064	.699	.058
Q9	.006	.846	-.014
Q10	-.164	.881	-.085
Q11	-.015	.560	.255
Q12	.062	.721	.184
Q13	-.176	.730	.011
Q14	-.048	.193	.713
Q15	.061	.096	.693
Q16	.827	.148	-.111
Q17	.877	.024	-.025
Q18	.853	.021	-.020
Q19	.811	-.006	.114
Q20	.705	-.041	.150
Q21	.765	-.054	.169

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.[a]

a. Rotation converged in 7 iterations.

Table 17: Pattern Matrices for 1-3 (a-b) Factor Constructs

c) **Pattern Matrix**[a]

	Factor			
	1	2	3	4
Q1	.014	-.076	.628	.104
Q2	-.057	.030	.542	.138
Q3	.185	.031	.453	-.085
Q4	-.019	-.106	.585	-.014
Q5	.040	.062	.045	.626
Q6	.062	.037	.026	.920
Q7	.032	.019	.058	.821
Q8	.127	.704	.007	.030
Q9	.070	.835	-.065	.061
Q10	-.121	.814	-.113	.129
Q11	.048	.597	.210	-.020
Q12	.142	.775	.124	-.028
Q13	-.114	.750	-.031	.005
Q14	-.013	.228	.684	-.020
Q15	.089	.131	.667	-.023
Q16	.805	.050	-.122	.166
Q17	.855	-.049	-.037	.128
Q18	.870	.015	-.058	.022
Q19	.826	-.004	.080	.015
Q20	.777	.068	.086	-.155
Q21	.783	-.038	.132	-.005

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.[a]

a. Rotation converged in 5 iterations.

d) **Pattern Matrix**[a]

	Factor				
	1	2	3	4	5
Q1	.033	.033	.682	.070	.153
Q2	-.037	.104	.576	.121	.091
Q3	.212	.098	.476	-.111	.076
Q4	-.001	-.110	.550	-.012	-.057
Q5	.016	-.111	-.014	.744	-.224
Q6	.070	.078	.047	.892	.097
Q7	.041	.099	.097	.797	.170
Q8	.139	.417	-.090	.140	-.562
Q9	.095	.633	-.088	.140	-.343
Q10	-.083	.821	-.065	.134	-.032
Q11	.059	.337	.129	.074	-.514
Q12	.183	.683	.130	.007	-.194
Q13	-.073	.972	.058	-.074	.174
Q14	-.012	.003	.612	.055	-.466
Q15	.102	-.023	.597	.031	-.329
Q16	.807	.057	-.099	.154	.061
Q17	.878	.041	.006	.085	.205
Q18	.868	-.089	-.091	.047	-.139
Q19	.829	-.039	.071	.019	-.035
Q20	.783	.013	.067	-.146	-.090
Q21	.793	-.025	.134	-.018	.037

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.[a]

a. Rotation converged in 13 iterations.

Table 18: Pattern Matrices for 4-5 (c-d) Factor Constructs

In addition, the pattern matrix for the three-factor construct retained from EFA has factor loadings higher than 0.30 (Table 18). Factor loadings from 0.30 and higher are considered significant (Gorsuch, 1983; Lichtenberger et al., 2017).

Factor 1		Factor 2		Factor 3	
Item	Rotated Factor Loading	Item	Rotated Factor Loading	Item	Rotated Factor Loading
Q16	0.827	Q5	0.434	Q1	0.596
Q17	0.877	Q6	0.549	Q2	0.514
Q18	0.853	Q7	0.491	Q3	0.472
Q19	0.811	Q8	0.699	Q4	0.584
Q20	0.705	Q9	0.846	Q14	0.713
Q21	0.765	Q10	0.881	Q15	0.693
		Q11	0.560		
		Q12	0.721		
		Q13	0.730		

Table 19: Factor Loadings for a Three-factor Construct

4.1.4 Conceptualizing the Three Emergent Themes

Figure 21 shows the conceptualization of the three-factor construct following agreement among multiple EFA extraction methods. The figure shows that the three factor variables are the emergent themes. These "themes" were conceptualized based on the combination of themes (further left) attached to the groupings of individual Likert-type "items" interlinked with the degree of "factor loadings" and "factors" (further right). Each factor represents one emergent theme. All items have loadings above 0.30. Loadings above 0.30 are considered to be significant. The solid lines with different thicknesses indicate the degree of significance of factor loadings ranging from 0.40–0.90. Thicker lines mean higher significance of factor loadings.

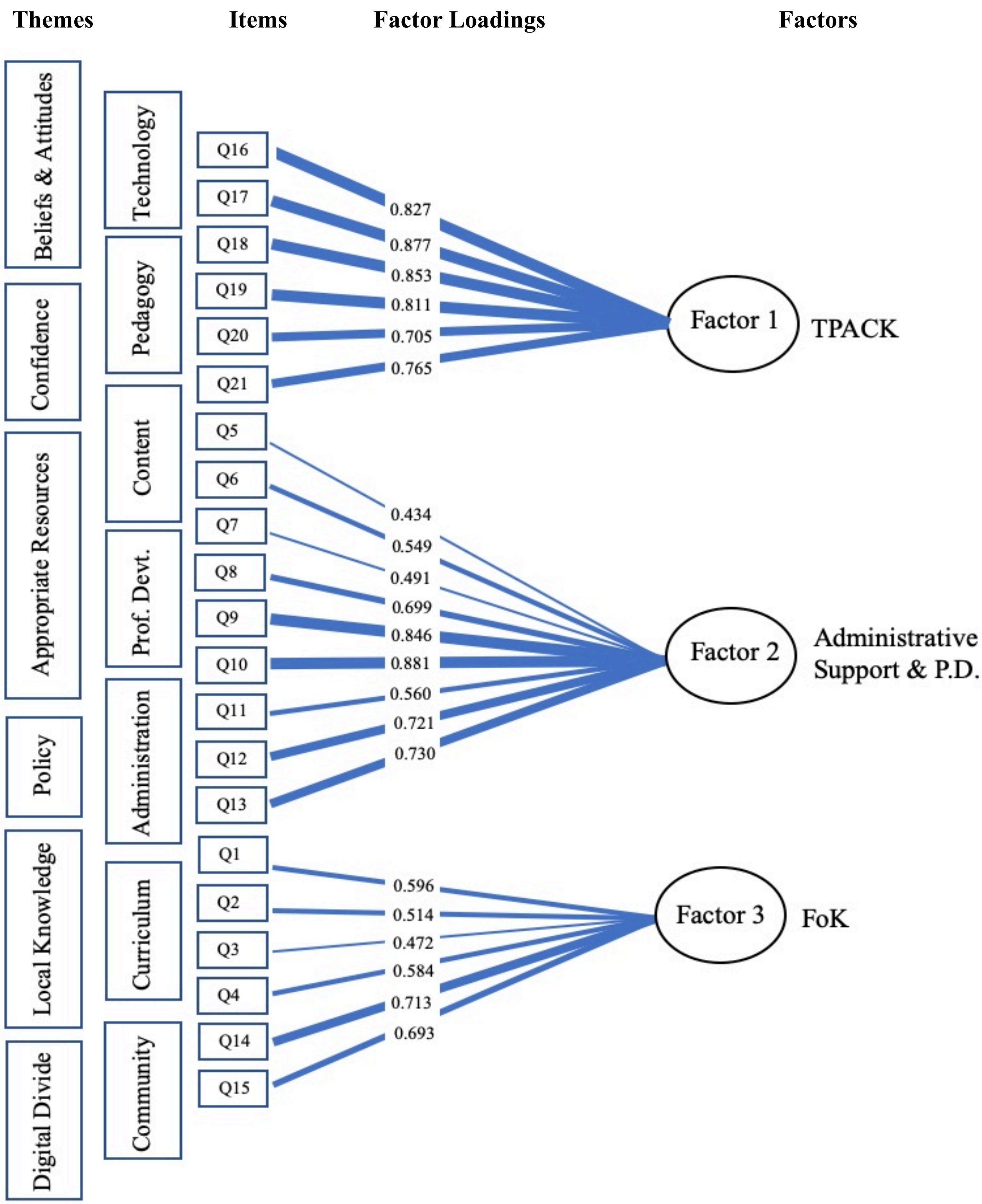


Figure 21: Factor Loadings with Corresponding conceptualization of Themes and Items

The three factors retained as explained above were now renamed as the three emergent and big themes (Table 19). They were teachers' TPACK, administrative support and professional development, and FoK, respectively. These factors stemmed from 13 overlapping sub-themes embedded in the 21-item questionnaire as summarized below. TPACK, containing five sub-themes, was now conceptualized as having the components of technology, pedagogy, content knowledge of science teachers, and their confidence, beliefs, and attitudes toward ICT integration in science class. These five sub-themes were conceptually interpreted based on the contents and themes projected by question items (Q16–21). For example, question items nos. 16, 18, and 20 asked for teachers' confidence in having technology and pedagogical content knowledge to use technology in their science class over the four weeks. Question item nos. 17, 19, and 21 had the same theme as that of questions 16, 18, and 20 but pertained to the period covered a year ago. Administrative support contained four sub-themes identified as professional development, policy, administrative support, and appropriate resources. These sub-themes were conceptualized from question item nos. 5–13. For example, using question nos. 5–7, teachers were asked to recall if ICT trainings from division, regional, and national levels implemented in their school were useful and relevant in science. For the third emergent theme, FoK contained four sub-themes which included digital divide, local knowledge, community, and curriculum. These sub-themes were generated using the contents found in question item nos. 1–4 and 14–15. For example, item nos. 14–15 asked science teachers whether or not they are convinced that students learn more about science if funds of knowledge are integrated with technology.

Emerging 3 Factor-Theme	13 Themes	Conceptual Interpretations
1. TPACK	Technology	Purposeful and deliberate use of technology, technology is understood as ICT and further specified only as laptop, LED TV, quality science textbooks and references, science laboratory equipment and materials
	Pedagogy	Techniques and methods in teaching science contents
	Content	Understanding the underlying concepts, principles, and theories in science
	Confidence	Self-reported attitude of relying on one's teaching experience and expertise
	Beliefs and attitudes	Self-reported tendency to value positively or negatively ICT as used for instruction
2. Administrative Support & PD	PD	Series of workshops, seminars and trainings to update content and pedagogical knowledge, and use of ICT
	Policy	Government directives, orders, and regulations regarding ICT initiatives in public schools
	Admin. Support	Division and school level support for teachers in the provision of appropriate ICT resources for teaching
	Appropriate Resources	Noting on the current infrastructures in public and rural schools, teachers wish for the appropriateness and usability rather than just the availability of resources
3. FoK	Digital Divide	The gap on exposure and utilization of ICT between teachers, students, and their community
	Local knowledge	The existing practices, values, wisdom and culture lived by the students, teachers, and all members of the community
	Community	A collaborative and inter-connected group (students, teachers, neighbors) living in one sphere of influence
	Curriculum	Pertains to the new K-12 curriculum where junior high school teachers teach other core science subjects outside their expertise

Table 20: Retained Three-factor Construct and its Conceptual Description

Summary of Key Findings

Using descriptive statistical analysis for questions on the teachers' demographic profile (Table 10) and exploratory factor analysis for questions related to challenges and experiences (Table 9), the following findings were generated:

(1) There were 141 public junior high school teachers in Region 6 who responded to the online survey. In terms of division level participation, Bago City, the central focus of this study, had 39 of its 45 science teachers volunteer to join with an 87% participation rate. Overall, 96% of the teachers owned a laptop and 81% did not have adequate Internet access. Most of the teachers (75%) used their laptop for video and PowerPoint presentations and nearly 72% (the highest for the group) suggested that they needed skills to create multimedia presentations. The top three FoK themes used by the teachers in their science classes were local geography, agriculture, and elders' beliefs including superstitious beliefs.

(2) There were three emergent themes (also called the three-factor constructs) identified: TPACK, administrative support and PD, and FoK. Science teachers' TPACK was conceptualized as including not only components of technology, content, and pedagogy but also teachers' confidence, beliefs, and attitudes toward ICT integration in science class. Administrative support and PD contained four sub-themes of policy, appropriate resources, and administrative support and PD. The third emergent theme was FoK. It contained four sub-themes of digital divide, local knowledge, community, and curriculum. All factor loadings for all the items used for the three-factor constructs ranged from 0.45–0.90. This range was considered significant to highly significant since factor loadings higher than 0.3 were considered significant (Lichtenberger et al., 2017).

In other words, each of the three-factor constructs was closely associated with every sub-themes and group of items converging to it, respectively.

Chapter 5: Qualitative Data Analyses

The qualitative analysis in this section is not a separate analysis of separate qualitative data coming from one-on-one interviews, five focus group interviews, and written observations and reflections in nine science video-creation workshops. Rather, these qualitative data were examined and coded as dictated by the three emergent themes (TPACK, administrative support & PD, and FoK) generated by EFA and described in the previous chapter. In other words, this section is an extended analysis which principally connects to the quantitative analyses in the previous chapter with the main guiding question: How do the three EFA-generated and emergent themes manifest in the science teacher-participants' one-on-one interviews, focus groups, field notes and memos, and written observations and reflections in science video-creation workshops?

5.1.1 Thematic Analysis: Emergent Themes

As a brief review, thematic analysis is a method for "identifying themes and patterns of meaning across a dataset in relation to a research question" (Braun & Clarke, 2013, p. 175). It is also a "process of analyzing data according to commonalities, relationships, and differences across a data set" (Gibson & Brown, 2009, p. 127). The process of looking and naming the themes across qualitative data sets in this study, pre-imposed by the EFA-generated themes, is viewed through the lenses of TPACK and FoK. The themes were generated using Corbin & Strauss's (2008) open-axial-selective coding. The reviews were conducted using NVivo's (Jackson & Bazeley, 2019) visualization methods like exploring and comparing diagrams, coding density strips, and word trees. Then, the themes and their narratives were approved by my supervisors, Dr. Milner-Bolotin and Dr. Nashon, two members of my three-member PhD Committee.

The open coding generated 20 themes with varying degrees of transcript files and number of references from transcript files attributed to them (Figure 22). The most referenced theme was "resourcefulness and creativity" with 60 transcript references linked to seven transcript files. The least referenced theme was "competitiveness with private education" with three transcript references linked to one transcript file. I identified the top nine themes based on the number of files and references attributed to them with corresponding memos and field notes. The top nine enclosed in a box were themes from "professional development" down to "resourcefulness and creativity."

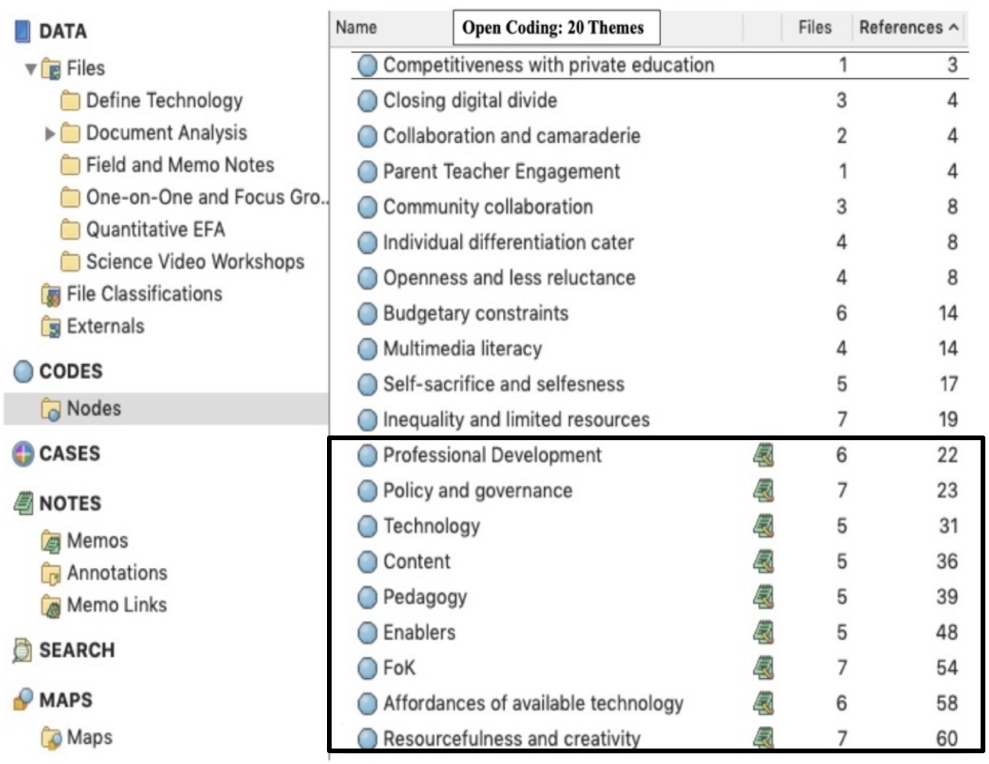


Figure 22: 20 Generated Themes from Open Coding Step

During the axial coding, the 20 themes were collapsed into five big themes. Further inspection of the five big themes and their sub-components reduced them into four themes (selective coding) (Figure 23). (Note: selfesness should had been written as selflessness)

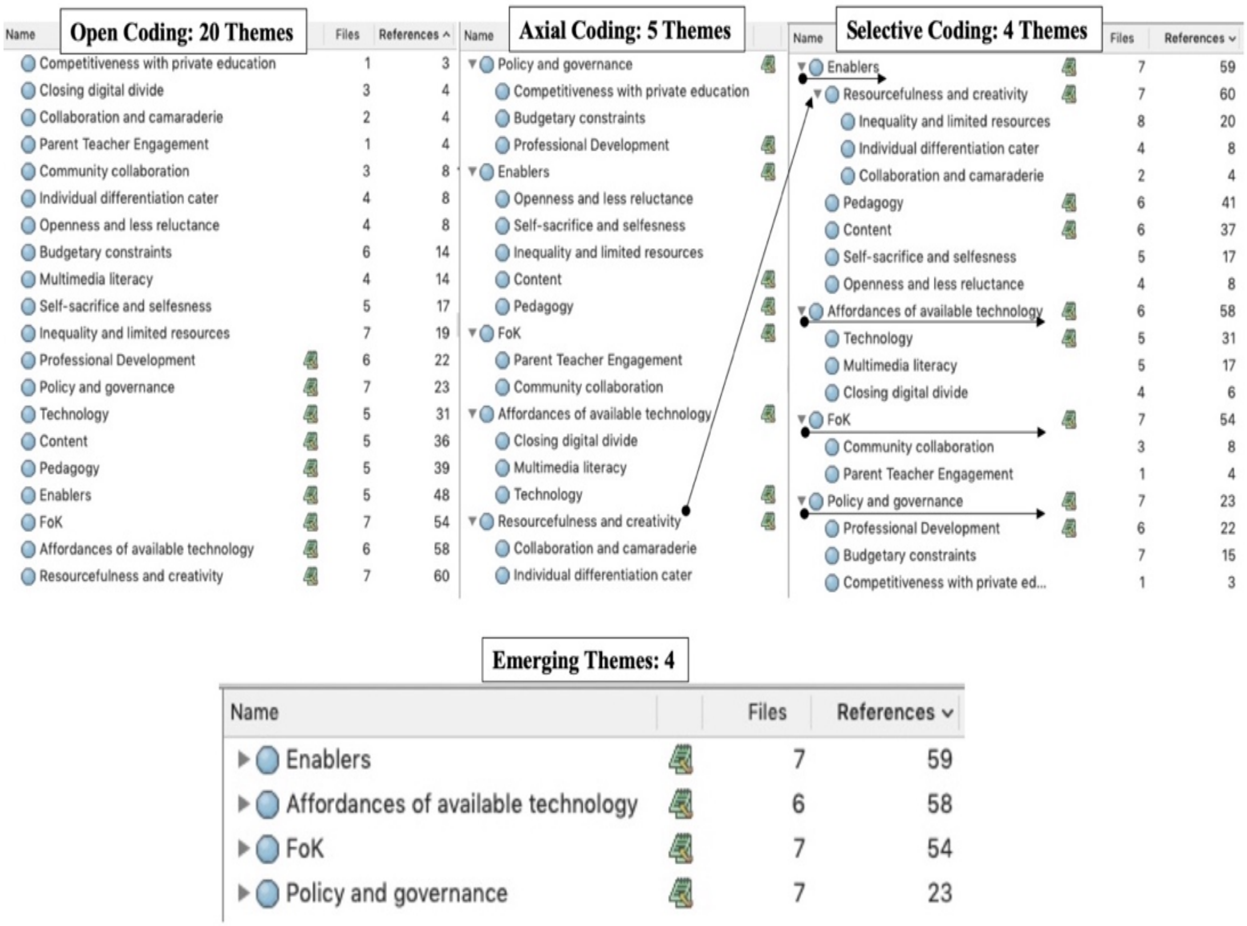


Figure 23: Emergent Themes after Axial and Selective Coding

I reviewed the four themes using NVivo visualization methods: exploring and comparing diagrams, and degree of coding strips. These visualization techniques complemented the existing underlying data sets from the transcripts. By looking into the hierarchical relationship of "enablers" and "resourcefulness and creativity" using coding density strips, one can see that the sub-themes under “resourcefulness and creativity” and individual themes like “content,” “pedagogy,” and “self-sacrifice and selflessness” were also coded under “enablers” (Figure 24). This provided one justification for me to attach “resourcefulness and creativity” under “enablers.”

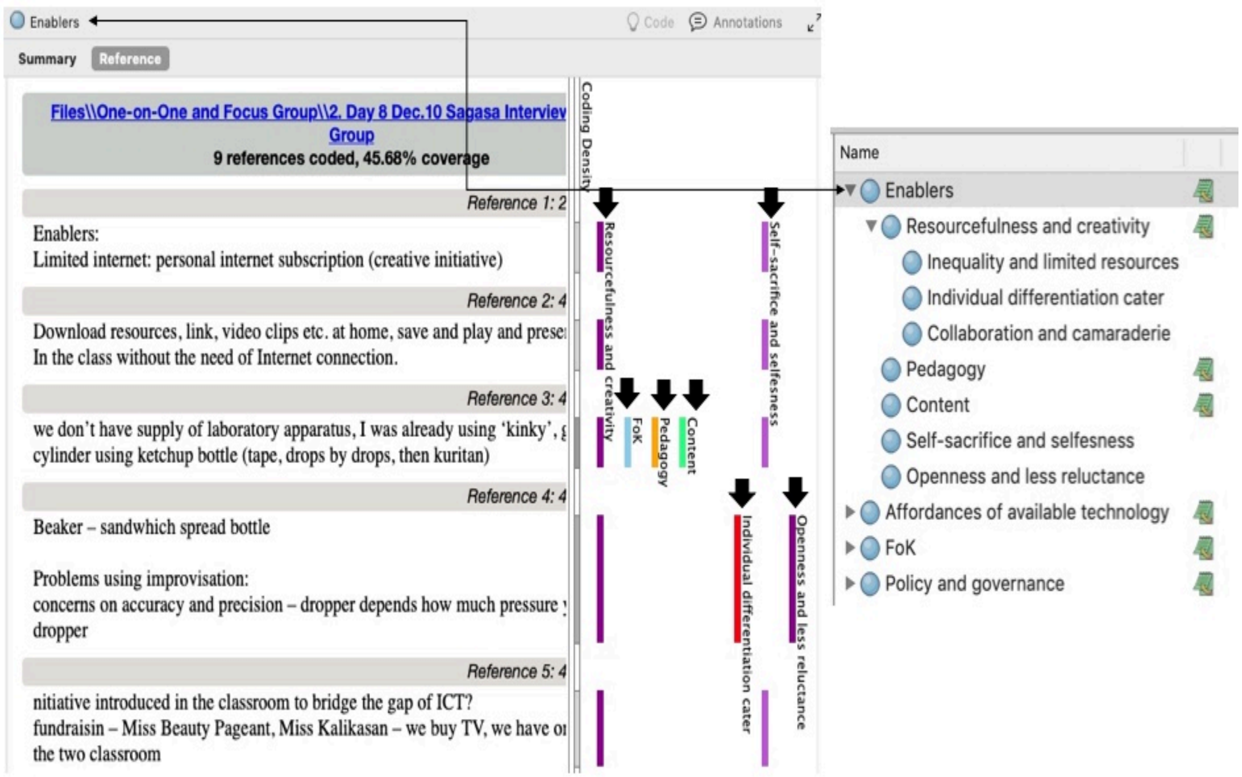


Figure 24: Visualizing using NVivo Coding Strips

Moreover, by connecting “enablers” and “resourcefulness and creativity” through a NVivo diagram (Figure 25), it can be seen that a considerable number of transcript files were connected to both big themes. These memos hinted at propositions that the limited availability of ICT resources compelled teachers to be resourceful.

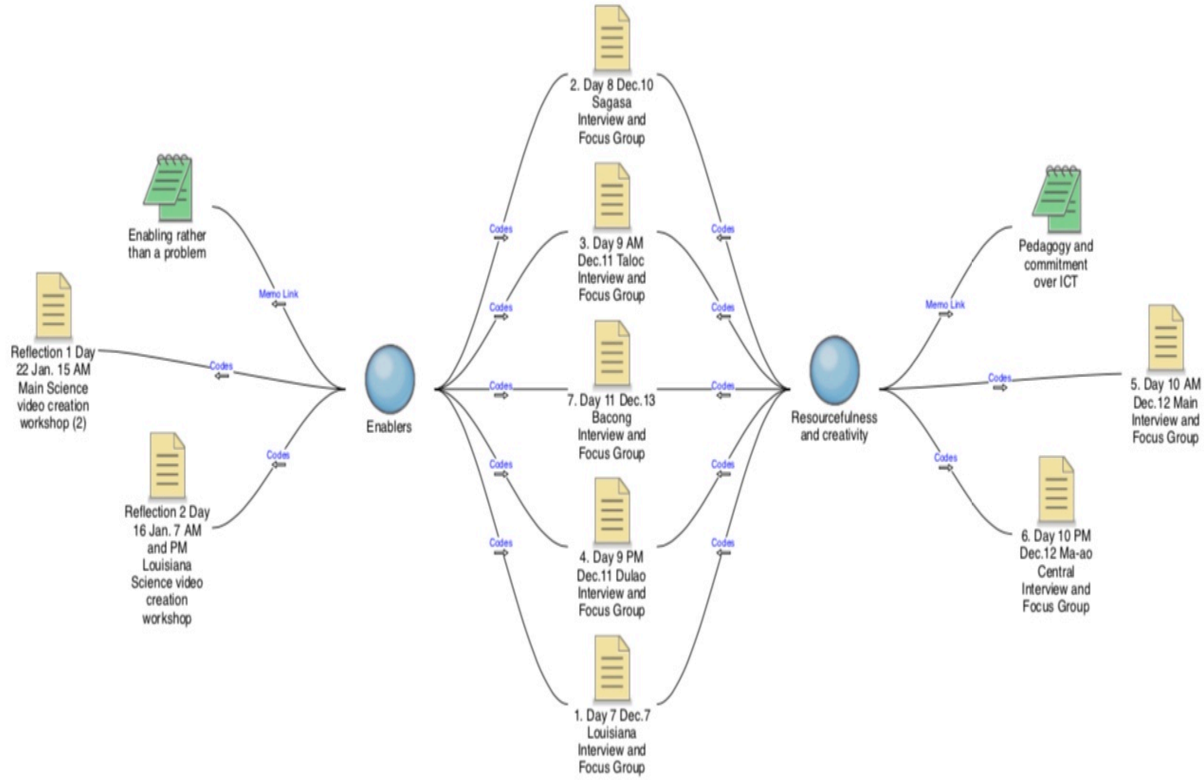


Figure 25: Visualizing using NVivo Diagram

Lastly, a detailed examination using the NVivo Explore Diagram showed that all the four emerging themes (with a star inside a blue circle) and their sub-themes were contained in one specific transcript file (Figure 26). This transcript file discussed several issues related to the challenges and experiences of science teachers in the use of technology, professional development, school and community support, etc. Evidently in this one day of interview and focus group sessions, the diagram indicated that most of the sub-themes were converging toward "enabler." This was followed by a tie between "policy and governance" and "affordance of available technology," while the least number of sub-themes was merging under "FoK."

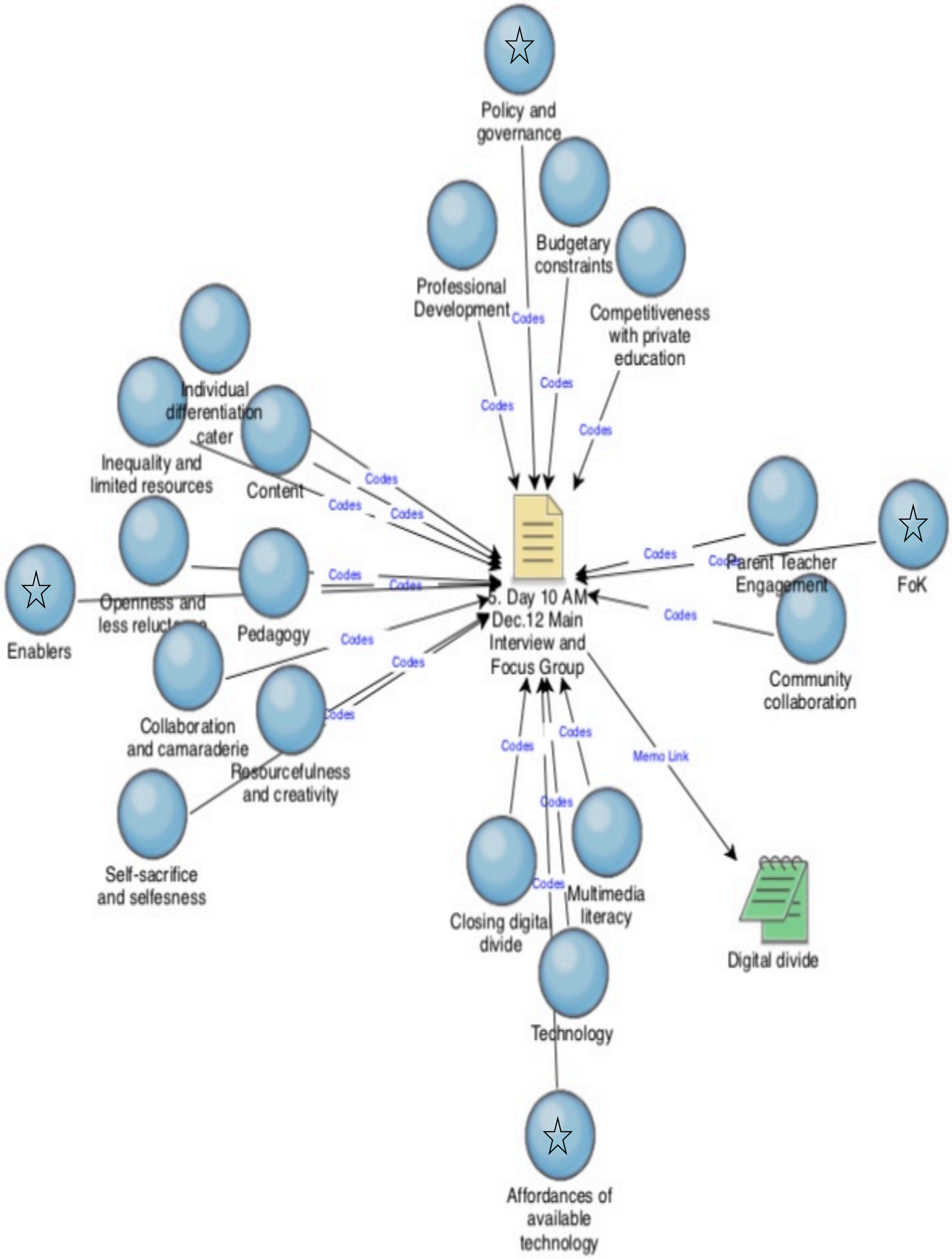


Figure 26: Visualizing the Four Emergent Themes and their Child Themes

5.1.2 Conceptual Interpretations: Emerging Themes

My physics class is more than just using a laptop and LED TV. I can still manage to use a Manila paper and post it on the wall.

Ms. A (Transcript 23/55, Dec. 12, 2018)

Four out of the 20 initial themes were named as emergent themes. These are:

1. Enablers
2. FoK
3. Policy and governance
4. Affordance of available technology

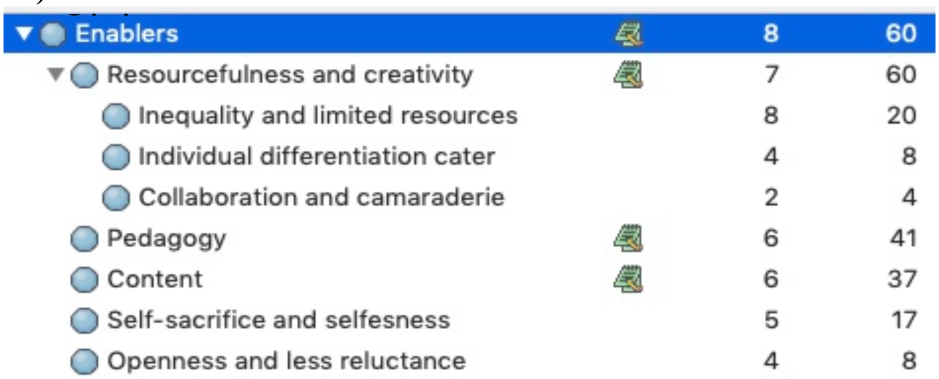
Theme 1: Enablers

This study adopted Campbell's (2018) and Oxford English Dictionary's (OED) (Enable, 2019) definitions of enable to frame the theme "Enablers'. In the context of democracy, an enabler is someone who encourages, innovates, and drives the quality of democracy (Campbell, 2018). To enable is equivalent "to giv[ing] power to (a person); to strengthen, make adequate or proficient, or to make competent or capable" (Enable, 2019). For example, enable was used in the sentence from H. Lawrence of Communion & Warre with Angels' (1646) as "It was all that Alexander had to inable [enable] him to conquest the world". Enable was used in a much earlier entry in 1581 from R. Mulcaster Positions xli suggesting "Exercise to enable the body".

Applying the definitions of the verb to enable as mentioned above, OED defined enabler as the one who enables. In one of the entries from W. Sclater Expos.1 Thess. in the year 1630, it proclaimed that "God, the onely enabler to so great performances" (Enabler, 2019). However, a negative connotation of the term enabler exists by describing someone who intentionally or unintentionally encourages or enables negative or self-destructive behaviour in another (Enabler, 2019). The earliest example provided by OED was an entry from the Los Angeles Times in 1979 stating "Don't be an enabler. That's an Alcoholics Anonymous word for someone who helps instead of hindering the drinker"

Drawing on the positive meanings of enable and enabler, the sub-themes like "resourcefulness and creativity," "openness and less reluctance," "pedagogy," etc. were descriptions of science teachers as encouraging, competent, and empowering as manifested through their actions, activities, and ideas implying a possibility for a thing or situation to happen despite difficulties and limitations in integrating technology in their science classes. These manifestations were coded as "enablers." This emergent theme was coded the highest along with "resourcefulness and creativity" 60 times and referenced in eight transcript files (Figure 27a). Including child nodes, the individual themes such as "pedagogy" and "content" occupied significant places relative to other themes like "self-sacrifice and selflessness" and "openness and less reluctance" when visualized using a hierarchical view (Figure 27b).

a) Detailed



b) Hierarchical View

Figure 27: Visualizing using NVivo's Detailed Listing and Hierarchical View

"Enabler" as an emergent theme stood as powerful description of the collective experiences of rural junior high school science teachers as they integrated technology in their science classes. Common among science teachers in a school or department or as individual teachers, "enabler" as an activity, idea, or action demonstrated the attempts of these science teachers in the rural areas to advance their TPACK.

The table below (Table 20) provides several examples of enabling ideas and practices while further examples of unique initiatives from individual science teachers included the following:

(1) Contacting former students, alumni, and parent-teacher associations for donations to purchase LED TVs and fund other necessary classroom renovations (e.g., classroom toilet, floors, or windows). Ms. A liked discussing physics principles with the use of videos with animations she pre-searched at home and projected from her laptop to the LED TV. Besides using the TV as a projector, she also used it for her PowerPoint presentations and short quizzes. Moreover, rather than spending hours making an illustration of a cell on Manila paper, she can now annotate a downloaded visual aid of a cell online.

(2) Providing one USB portable drive to each student leader in a group for projects and enrichment activities. Students in a group brainstorm the appropriate content needed for the activity or assignment, then use an Internet café outside the school or in a nearby city to gather content online. They then submit their USB drive back to the teacher. This is another unique use of a USB portable drive in rural schools, according to Ms. I. Since students do not have enough money to spend on photocopying, the USB is now used to save science activities and student research so Ms. I can conveniently access them on her laptop.

(3) Inviting resource persons in the community to talk in their science classes (e.g., farmers, poultry owners). Ms. G realized that some concepts in biology can best be learned by having an expert talk to students face-to-face rather than by using a video or PowerPoint presentation.

(4) Using local and native fruits and plants as a model for body organs. Visual aids can be downloaded online, but Ms. D emphasized that she also uses local plants as a substitute for digital photos to model or explain a science concept.

(5) Printing activity materials at home in advance for each group of students in the class.

(6) Using empty condiment bottles as improvised beakers and test tubes.

(7) Bringing local plants and fruits into the class to test them as either acids and bases instead of using litmus paper, which evidently the school does not have.

Difficulties/Issues	**Enabler: Idea, action, activity, person**
No photocopying machine	**Science department holds "Science Beauty Pageant"** * Tickets were sold to students, parents, and the community * Proceeds were used to purchase second-hand copier machine * Teachers accept requests for photocopying services (for payments) from students, teachers, and staff in the school. * Proceeds are used to buy science instructional materials e.g. LED TV monitor
One LED TV for the whole Science Dept.	**Exchange of classroom** * To minimize movements and damage, LED TV is placed stationary in one classroom * Teacher arranges with the other teacher to use TV in advance * If they will use at the same time, they exchange classrooms * During students' movement, questions are given out for students to discuss with a pair to minimize loss of instruction time
Creating improvised Department Room	**Construction of an improvised structure** * Teachers needed one common place where they can huddle * A room where they can conveniently exchange ideas, teaching strategies, etc.
Teaching expertise needed	**Resource persons** * Science teachers were not expert in some other science core subjects, so they requested one another to be a speaker or guest lecturer in their class
Promote interdisciplinary skills of students	**Scilympics** * Science department joined Science Olympics (Scilympics) to support students in looking for ideas for song entries * Integrated dances, choreography, science concepts, and music

Table 21: Examples of Teacher Difficulties and Their Enabling Actions

Interestingly, the teachers shared the above enabling ideas through storytelling and classroom anecdotes rather than a typical interview where the interviewee enumerates the answers to the interviewer's point by point. Teachers' methods of responding to questions helped contextualize the interviews in a particular way for both interviewer and interviewee. As a social practice, we were equally able to see the process as a co-construction of knowledge and not as a process of merely accessing or providing knowledge. This aligns with Talmy's (2010) claim in reference to Holstein and Gubrium (2003) that when interviews are viewed as a social practice, the interviewer-interviewee becomes a co-creator of knowledge. Similarly, I deliberately looked at science teachers as research participants and subjects (noting my own identity shifting from insider and outsider status to a space in-between) and not as respondents. Through the acknowledgment of teachers as collaborators and co-creators of knowledge, interview transcripts were transformed into voices of experience and expertise. Several teachers narrated how they were becoming resourceful and creative in preparing and delivering their lessons despite limited or no availability of ICT-based teaching resources. For instance, a group of science teachers bought a pocket Wi-fi or dongle pre-paid Internet device for their science classes. They took turns in reloading data to the device using their own money. Ms. A explained how fellow teachers improvise with a limited Internet connection in school:

> Most of the time we have our classes in classrooms adjacent to one another, so we can easily share Internet access… But we could not completely rely on the Internet connection via a dongle. That is why my physics class is more than just using a laptop and LED TV or Internet. I can still manage to use a Manila paper and post it on the wall… With limited technical or professional support, sometimes teaching boils down to what we call *diskarte* [teacher's craftmanship and strategy].

In Ms. B's school, science teachers use *tarpapel*. It is a combination of the word tarpaulin (tar) and *papel*, which is a Filipino term for paper. It is a low-cost alternative to tarpaulin for classroom visual aids. “It is easy to prepare and print besides being environment friendly, cheap, and more appropriate for short term use,” Ms. B suggested.

During regular class days, in Ms. B’s school, a remote public school overlooking the majestic peak of Mt. Kanlaon, one science teacher might be at the kitchen preparing lunch for everyone while the other is photocopying class notes for students. Teachers usually take turns bringing goods and ingredients for lunch, and the earnings they get from photocopying (from students and colleagues) is their source of funds for science instructional materials. The science department head, Ms. C, revealed:

> We collected proceeds from ticket sales during our “Science Beauty Pageant” and we used them to purchase a second-hand photocopier. With the machine, we generate extra source of funding that later on might afford us to buy quality reference books and additional LED TV.

These teachers decided to stay in an improvised, temporary bamboo structure attached to the end of a classroom as a science department faculty room. It is an open structure with a roof. The walls are made of strips of crisscrossed bamboo. Students looking for their teacher just need to stand outside and call out; they do not need to enter the room. Seven science teachers including the department head share the room, which is approximately 6x10 meters. It has a small kitchen and two connected tables made of bamboo at the center of the room for meals and meetings besides teachers’ individual working tables and second-hand copier machine. The room is packed with seven teachers all sitting with their laptops, notes, test papers, etc. However, they would rather stay here where they can always gather rather than being alone in their classrooms.

In the words of Ms. C, the department head, it is “a place where they can harmoniously live and work like home and allow each one to grow as a community of professionals.”

Some creative ideas by teachers like Ms. A, who started using an LED TV monitor to connect with her laptop instead of a projector, have been replicated by other science teachers. In Ms. A’s school there are now three classrooms that have mounted TV screens on their walls and more science teachers are looking for funds to buy LED TVs as well. The enabling actions of the science teachers to improve science teaching and learning in rural schools were manifestations of their resourcefulness, creativity, self-sacrifice, openness, and selflessness.

Theme 2: Funds of Knowledge (FoK)

FoK as contextualized in education (Gonzalez, 1995; Llopart & Esteban-Guitart, 2018) and practiced by science teacher-participants was coded 54 times and referenced in seven transcript files. It has two child nodes: “community collaboration” coded eight times from three transcript files and “parent teacher engagement” coded four times from one transcript file (Figure 28).

Figure 28: Theme 2: Funds of Knowledge

Data from the interviews, focus groups, and science video-creation workshops from two separate schools showed 51% (Figure 29) of the total transcripts from each school attributed to FoK alone.

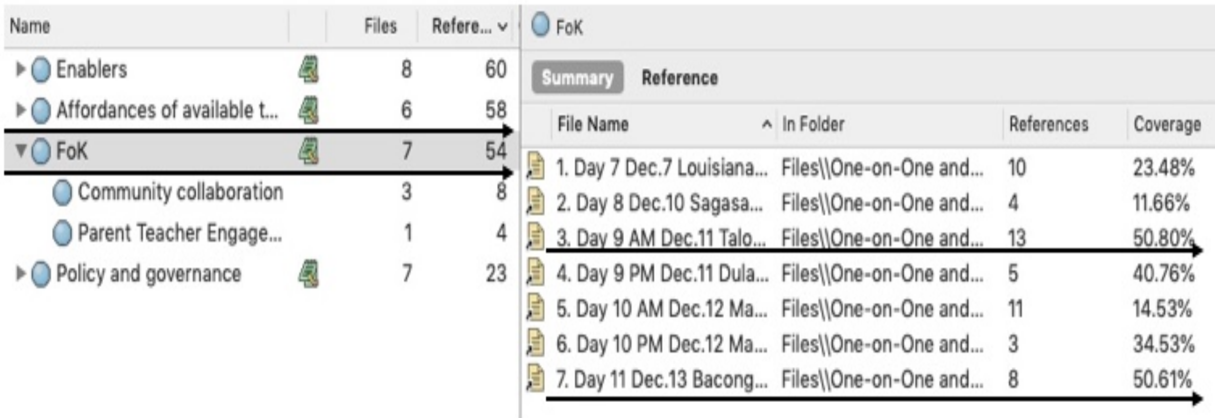


Figure 29: Theme 2 "Funds of Knowledge as a Common Topic"

The majority of the teachers provided a list of reasons why they are integrating FoK in their classes. Ms. D shared:

> Our students know lots of ideas from abroad through social media platforms but missed information within their community. So, when we use local knowledge in our science class, they start to realize the value of their community, etc.

Ms. E agreed with Ms. D, recalling a recent incident in her class:

> In order to provide [the students] some background about acid-base properties of substances, I brought mayana leaves (scutellarioides). Students did not realize that mayana can be used as an alternative for litmus paper.

Ms. D said that when she started to praise a student who told the class about their mayana plant, two more students raised their hands and informed the class that they heard the Malabar spinach they had at home could also be used as an alternative for litmus paper. "Whether it was true or not, I sense that students are becoming receptive of sharing ideas and stories about home and family, and I am glad that they are learning science at the same time," said Ms. D, assuring me that her science class provides opportunities for students to connect with their community and surroundings. This revelation from a science teacher like Ms. D indicated that students have resources that can be used to motivate engagement and nurture learning in the class. Consistent interactions of this kind in the classroom will create a bridge that fosters a mutual teacher and learner relationship (Gonzalez & Moll, 2002).

For Ms. F, the use of FoK in her class allows students to quickly grasp some science concepts, as she uses specific examples from the locality that students really know. "The pacing of discussion is smooth and fast. You can touch more issues and topics related to one science concept because they can make connections," Ms. F enthusiastically explained. Expanding on this idea, Ms. G stated:

> Our city is rich in agriculture activities like rice farming. So, if we teach biology in connection with rice farming to our students, then chances are these students might look at their parents' ordinary rice farm in a scientific perspective, for example, knowing the advantages of using organic fertilizers. Then, science could be a meaningful subject for the students.

Ms. A also shared some specific examples of how she used FoK, this time in conjunction with the use of her laptop and new LED TV. "You see, this is my grandfather's town. I can't imagine that it was that close to the epicentre of an earthquake!" one student exclaimed to her classmates, pointing at a map projected on a TV monitor where three circles overlapped showing data plotted from the Philippine Institute of Volcanology and Seismology (Phivolcs, 2019). "Immediately after the three circles were drawn representing the three different locations where the earthquake was felt," Ms. A proudly explained, "the students in the group started to retrace and identify the towns in the circles affected by the earthquake using some clippings from a local newspaper." In the past, she stated, "I just hung an MP3 (a local curricular term describing Manila paper folded in three parts) on the chalkboard and explained how data triangulation can be done to search the location of an earthquake." By contrast,

> For the last two years, using an online resource and TV monitor as projector, I was able to allow students to experience how to triangulate the data collaboratively. More importantly, the students have expanded the activity by raising critical conversations involving the structural integrity of local houses, their location relative to a known fault, and the community's sense of preparedness for natural calamities.

As regards natural calamities, Ms. H recalled that "if our lesson is about classifying volcanoes in terms of their activity (active, dormant, or extinct), we don't need to go far and cite world-famous volcanoes but just glance at the volcano from the window of our classroom." She provided a fitting example:

> Localization in science education means science literacy. Familiarization of their surroundings is critical for their safety and survival. Our school might be within the danger zone, and so when our students are already aware of the danger, they can respond quickly and evacuate.

One last concrete example of integrating FoK into science class was given by Ms. I. She shared an instance when she had asked her students for their ideas about comets. Confidently citing their elders, students stated that the sighting of a comet with its tail pointing downward signifies a bad omen. When Ms. I asked them the scientific explanation for the occurrence of a comet, students simply stared at her in silence. When she explained the natural and predictable occurrence of comets, she noticed that students were seemingly unconvinced. In the latter part of our interview, Ms. I tried to recall what she did in the class that day, exclaiming, “I should have shown some diagrams or videos on how comets appear and disappear in the sky!” Ms. I’s reservations regarding the use of FoK in science class echoed what I heard from other teacher-participants. She said:

> FoK bridges respect between teacher and students, school and community. It promotes valuing of students’ and teachers’ identity… students’ science literacy and reasoning. The downside is that, when students have high regard and respect with their elders, they’re not inclined to consider other truths, like scientific beliefs.

FoK as a theme and as a teaching practice was widely visible among the science teachers in the rural areas. However, the teachers rarely called it as FoK. The DepEd in the Philippines termed it as contextualization, indigenization or localization. Regardless of differences on the use of terminology, the teachers considered FoK as a bridge for science literacy, community collaboration, and parent-teacher-student engagement.

Theme 3: Policy and Governance

Policy and governance as an emergent theme involved three child themes: professional development, budgetary constraints, and competitiveness with private education (Figure 30). This theme was defined as directives, executive orders, and initiatives from the national DepEd level cascaded down to the classroom level. The theme also covers the wishes or perspectives of science teacher-participants regarding professional development and training, limited ICT resources due to budget constraints, and the challenge of preparing rural public high school students to be competitive with their counterparts in private schools.

▼ Policy and governance	7	23
Professional Development	6	22
Budgetary constraints	7	15
Competitiveness with private education	1	3

Figure 30: Theme 3 "Policy and Governance"

Under this theme, Ms. A's case resounded clearly. In her classroom, Ms. A has a wide flat screen TV mounted on the wall connected to a laptop on her desk. One side of the room displays images of her favorite Filipino and foreign scientists and physicists. When I visited her classroom, there was big box on one side of the room. Seeing me glance at it, Ms. A proudly volunteered, "That box was an old TV I bought but the one on the wall is the newest. That's given to me by my former advisory class as a birthday gift." She explained why she initially decided to buy a LED TV:

> I stopped using a multimedia projector. Recently, the bulb was damaged. Too much movement and transfer. Well, the bulb has expiration and there was no more replacement provided by the department… [Using a TV instead] was very convenient, no more advance requisition, and the time and energy I save in transporting the projector from the office to my classroom and back is spent more with the students.

Ms. A revealed to me that she just started using a multimedia projector with a laptop in 2015.

Though she is retiring in 2–3 years, she has a more demanding workload as a specialist for the school's special science classes. She is doing her best to prepare her students to be highly capable and competitive when they reach college. With her new wide flat screen monitor permanently fixed on the wall, she can maximize her time by concentrating more on designing activities and reviewing her PowerPoint slides or online resources for her class. Some of her colleagues, seeing the comfort and benefits of using an LED TV monitor compared to a projector lamp, have gradually started following her practice. Ms. A's case is an example of a teacher-driven initiative born out of need rather than handed down as a government-wide initiative. As of 2019, no such government initiative had reached Ms. A's school. She shared her perspective:

> The technology I use in my science and physics class is just a tool that would bridge learning between me and [students]. I just wish that ICT investments in public schools should focus on teachers' professional training more than delivering computers and gadgets in schools for students.

Before 2015, Ms. A already had a desktop computer in her house. She used it to type up her science activities and quizzes. Besides attending ICT workshops at the university in the capital city of the province, she learned the basics of MS Word, Excel, and PowerPoint from her sister. For the rest, she said:

> [I'm] exploring how PowerPoint presentations can attract attention of my students. They are in fact more adept at PowerPoint. By making PowerPoint [presentations] on my own, I send messages to them that we have some common interests with technology.

Ms. A ended the interview by sharing her passion for teaching: "We are doing our best in our special science class, hoping that students might become future engineers and scientists."

Several teachers have attended ICT training conducted by the school divisions. The training covered how to use programs like Microsoft Word, Excel, and PowerPoint. Teachers were grateful to the division office for providing them training in the use of Excel for their e-student class records, test scores, and grade computation. In addition, Ms. D was hoping that more households within the vicinity of the school would advocate for Internet subscriptions. “If the subscription reaches a minimum quota, then an Internet provider would bring the service to the community and that means our school could also be connected to the Internet!”

Ms. B stated that to compensate for the limited number of textbooks in the class, she often took screenshots of the text then annotated them and projected them onto the board. However, unlike Ms. A, who has a fixed TV monitor mounted on the wall of her classroom, Ms. B has to share one TV unit with six fellow science teachers. When they need to use it during the same period, teachers must switch classrooms in the middle of the class rather than transferring the TV unit from one classroom to another. In order to minimize the loss of instruction time while students change classrooms, teachers give out guide questions about the video for students to think about. “We could not produce another TV unit but we could always create appropriate strategies for students to continue learning,” said Ms. B, offering a positive proposition instead of complaining about the scarcity of resources at the school. Most of the time, Ms. B and other teachers at this school have to download online resources in advance at home, since the Internet is not available for classroom use except in the school’s computer learning resource room. The computers in this room are mainly used for administrative purposes. The science teachers at this school speculated that interactive science lessons via online sourcing or digital whiteboards would not work there, and even videos to be used in class had to be downloaded at home and played as a saved document rather than as an online link.

With the current infrastructure of the school, what teachers really need is content and pedagogy training, particularly for junior high school teachers like them who have to teach other core science subjects outside their field. They need a comfortable science teachers' room where they can gather and confer regarding specialized science content and strategy, with quality reference textbooks and laboratory equipment. As a former K-12 teacher, I agree that the provision of computers for students is a welcome initiative. However, with the lack of Internet access, unstable power supply, limited ICT training programs for teachers, and demanding teaching loads, computers might not be maximized for learning. This apprehension echoes the World Bank Report (2017) which cites studies that many of the ICT interventions in education "fail or stumble badly before being implemented" (p. 146). One reason for this is the failure to focus on technologies that are realistically feasible in current and existing systems. For example, introducing technologies in rural school classrooms might be more attractive "because of the weak education system…but this system itself (i.e., limited access to electricity or Internet connection) has the least capacity to support education technology interventions" (p. 147). Public officials in developing countries who invest highly in education technology may derive "political returns from flashy technological interventions, independent of their usefulness for better learning" (p. 147); in other words, politicians aiming for highly visible investments may miss the opportunity to contribute to real learning in the classroom if new investments do not consider the current realities of the school system. There may also be issues with school administrators who are unrealistically optimistic about the transformative impact of technology in schools.

Theme 4: Affordances of Available Technology

The fourth emergent theme was affordances of available technology. It included three child nodes: “technology,” “multimedia literacy,” and “closing digital code” (Figure 31). Affordances of technology as verbalized by science teachers revolve not around “available ICT resources” but rather around “appropriate ICT resources” in school that can be maximized for students’ learning and teachers’ professional growth. Echoing her fellow teachers, Ms. B explained that such “appropriateness” means “ICT investments should concentrate on improving their PCK especially on science subjects that they are assigned to teach yet outside their expertise.” It also means ICT should be appropriate within the school’s current physical infrastructure. It is impossible to maximize the computers available if there is no Internet connection in the school.

Affordances of available technology	6	58
Technology	5	31
Multimedia literacy	5	17
Closing digital divide	4	6

Figure 31: Theme 4 “Affordances of Available Technology”

Turning once again to the example of Ms. A’s LED TV, Ms. A told me that she originally thought of using the birthday funds gifted to her by her former students for an air-conditioning unit for her classroom. However, she realized that the school would not allow this, as it would increase the school’s electricity bill. So, instead of an air-conditioning unit, she decided to purchase a LED TV. She realized that the TV was more appropriate for her science and physics class, since it would enable her to quickly connect with her laptop to show videos and

PowerPoint presentations, and would save time and energy compared to her old multimedia projector.

Another concrete discussion on the affordances of appropriate technology took place with Ms. J. She was using a weather application downloaded on her phone. The weather app monitors cloud formations, shows up-to-date weather reports and hazard areas, etc. She introduced her science class to the app, demonstrating for her students how to locate nearby weather monitoring stations. The students were surprised to learn that even shopping malls in the city have weather monitoring stations. Accessing the weather app via a phone was not a problem among students as long as they were connected to the Internet. Almost all students have mobile phones. All teachers have mobile phones. Some teachers have more than one mobile phone unit. This is not surprising in the Philippines, even for rural public high schools. Based on a recent survey, Philippine mobile phone subscriptions sit at 114 for every 100 Filipinos, outnumbering the national population (Mirandilla-Santos, 2016).

Ms. J teaches at one of the luckier schools in the division, with a relatively stable Internet connection. The school is sandwiched between two nearby cities. One of the two cities is the capital city of the province, and so the two national Internet service providers are also available. The other city is Bago, the site of junior high school teachers participating in the study. The school administration was quick to take advantage of this opportunity by making sure that the school could also get a better Internet connection. Ms. J pointed out:

> Although we need more LED TV monitor to be installed in each classroom for better video or PowerPoint viewing, our school has already an e-library. With this facility, I

> make sure that when students go online, they have very specific objectives on what to look for. I train them to be information or media literate!

In the case of Ms. B, her school has a full-time IT staff. Unfortunately, the available Internet was only accessible in the computer room, and this room was only available for administrative purposes and computer classes. There were reports that more computers would be delivered to public schools by the DepEd; however, Ms. B and her fellow science teachers were skeptical as to how they could maximize the computers in their science lessons when there is no Internet connection in their school. During our science movie creation workshops, they had difficulties in accessing photos and diagrams online. Although the video-editing software worked without an Internet connection, trying to find and download media resources needed for the video-making process was challenging and frustrating. Ms. B suggested that "with the current infrastructure in the school, what we need is content and pedagogy training."

Ms. K, a co-teacher of Ms. B's, also speculated on the issue of computer provision for students. In her view, "the distribution of computer in schools is a reasonable initiative." However, she believed that "with the limited technological infrastructures for Internet access and limited ICT training for science teachers, computers might not support students learning." She said that one better way of reducing the teacher-student digital gap and improving teachers' multimedia literacy is for the government to invest more in teachers' professional development related to ICT, not just in delivering computers to schools to reduce teacher/student to computer ratios. While Ms. K was making her final edits on her video piece, she said: "Though I am still struggling on how to annotate, edit my storyboard, I think in the long run, having know-how on video editing is an edge."

As science teachers engaged in video creation (on any topics in General Science to Physics) from pre-production to post-production, I made an Observation Protocol Matrix (Appendix H) on the extent of integrating ICT using the Adoption and Use of ICT by Morel's Matrix (Center for Research, 2009). The matrix was converted into a visualized radar chart (Figure 32). For every stage, from "emerging" (the lowest stage) to "transforming" (the highest stage), I assigned points for every teacher from 1–50, where 1 is the lowest manifestation of using or exhibiting skills in ICT and 50 is the highest. It should be noted that most of the teachers belonged to the emerging and applying stages with points of 20 and higher. Only a handful of them had reached the "integrating" and "transforming" stages with points around 10 and below.

The "emerging" stage is the lowest stage in the adoption of ICT. One manifestation of this stage is that science teachers start to realize several areas and/or aspects of their science teaching where they can make use of ICT. Science teachers expressed several possible situations where they might use ICT, and this explained why the radar chart showed higher levels at the "emerging" stage for all teachers (from Ms. A to Ms. J). It was exhibited by more than 75% of teachers, who expressed belief in the potential of Camtasia and Snagit (Techsmith, 2019) for creating visual aids and demonstrating science concepts using video. This was their first time using the editing software. Some of them even suggested making videos for school reports and activities submitted to the division school office annually.

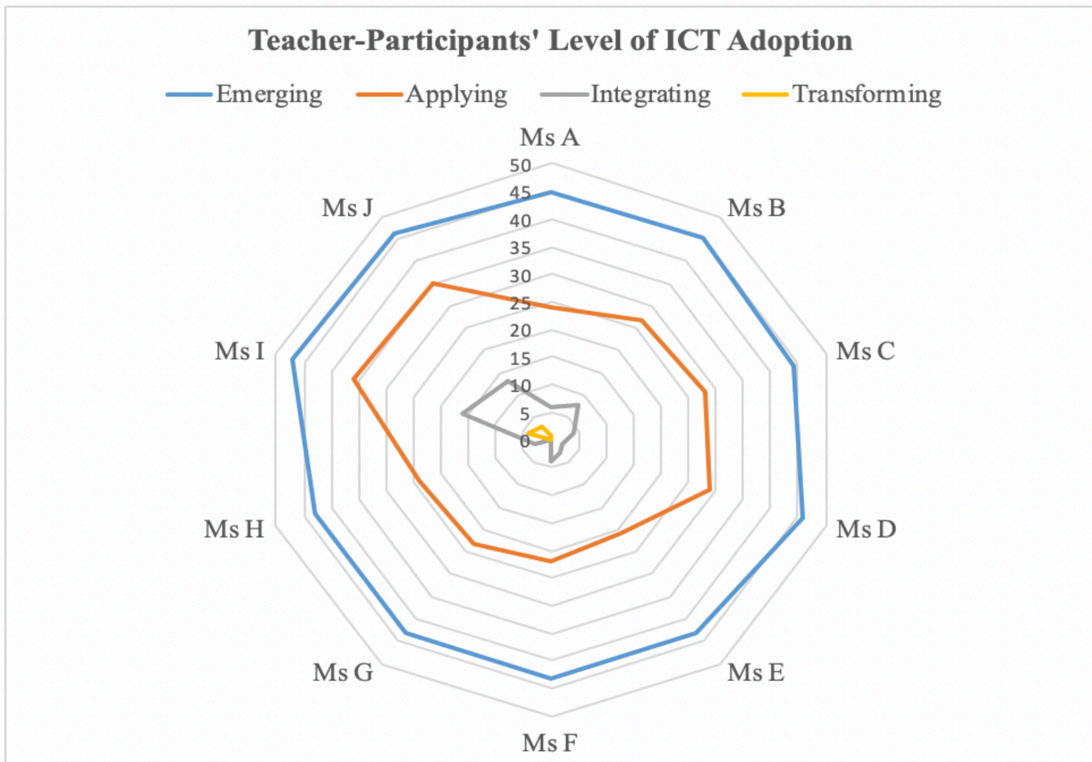


Figure 32: Science Teacher-Participants' Level of ICT Adoption

Meanwhile, more than 50% of the teachers were in the "applying" stage. They were already using specific functions and features of the software to annotate and design the photos and videos that they planned to show to the students. When I asked Ms. I why she placed an annotated photo of a broomstick labeled as a comet's tail beside a screenshot of a comet with a glowing head, she said,

> Well, according to our elders and students' grandparents, the tail's comet is like a broomstick. As a broomstick, it sweeps the blessings out of the community. That's why elders warned that the appearance of a comet with a tail pointing downward means famine or death in the community or wherever the comet would land.

Ms. I's narration and annotation using a superstitious belief embedded in her community's history was a way of concretizing the implementation of conceptualization in science in the new curriculum. Using community beliefs and practices to establish connections in science and to help students develop science literacy and value Filipino identity is clearly aligned with DepEd's new K-12 curriculum (Morales, 2016). This use of ICT is part of the applying stage.

"Integrating" is the 3rd stage in the ICT adoption matrix, and only around 20%–30% of teachers had reached it. As the name suggests, teachers should integrate a number of ICTs in their lessons aligned to a curriculum. Ms. I's video which integrated local beliefs about the appearance of a comet in the sky resulted in a higher spike of her score under the "integrating stage" compared to other science teachers. However, Ms. I recognized that her video might be more impactful to the students if she used it in conjunction with an invited elder from the community speaking directly to students about the beliefs elders hold related to the appearance of comets in the sky; she plans to do with her class next year. Moreover, Ms. I noticed that while Camtasia and Snagit allowed her to present colorful photos of volcanoes, these tools could not replace the experience and learning that happens when students present a role play about how people react when a volcanic eruption takes place in their town. She explained: "Our bolo (knife) can cut a Papaya tree easily but it could not explain how and what cells are made of. There is a limit what a technology can give and do."

Ms. I was touching on a crucial issue: different forms of ICT have different affordances and constraints. If Butterfield and Ngondi's (2016) definition of ICT is adopted and ICT may cover computers, the Internet, television broadcasts, and even printed or handwritten notes, then the inclusion of printed and handwritten notes would mean that teachers have already reached the integration level and some of them might be in the last stage already—the "transforming" stage. For example, Ms. A has used graphing paper and compass to extrapolate and triangulate earthquake data. However, if OECD's (2018) definition is followed—that is, if ICT is categorized as having three components (i.e., information technology equipment which includes computers and related hardware, communications equipment, and software)—then most of the teachers would be in the "applying" stage.

5.1.3 Science Movie Creation Workshops

The science video-creation workshops (Appendix F) as a quick review were composed of spiral progression sessions as follows: (1) pre-production, which included several sub-steps such as a) taking, editing, and annotating screenshots of still pictures, b) recording and editing audio and video clips, and c) storyboarding; (2) production, which involved the actual arranging of media along with the storyline; and (3) post-production, which included a review of the final video, presentation, and evaluation. Teachers were encouraged to limit their videos to 3–5 minutes. There were 8 sessions conducted, and each session lasted 2–5 hours each. In each session, prior to the start of pre-production, the teacher-participants and I had an informal dialogue about FoK and how they used it in their science class. The conversation was a platform for the teachers to affirm their contributions to the teaching profession. I also used this platform to inform them that each of them was a co-creator of knowledge and the series of videos they created would represent the richness of their experience.

The pre-production session was the longest part. It occupied almost half of the total time of the sessions. We spent a long time in creating the storyboard. Teachers understood the rationale for this. Developing a well-planned storyboard, anticipating what was needed in the video-creation proper, and carefully considering students' needs in the context of the videos were all crucial elements of locally based learning through videos. The teachers worked either individually or in groups. They verbalized their ideas for the storyboard using index cards and colored pens. They brainstormed how to compress a typical 20–30 minute science class discussion into a 3–5 minute video. The most common topic that was made into a video was that of comets; there was a teacher or a group of teachers in each of the five schools who created a video about comets. The superstitious and scientific beliefs related to the appearance of a comet were emphasized in the videos. Initially, this was a topic I suggested to the teachers during pre-production. I made the suggestion in reference to the interviews I conducted with them, noting that students have strongly held superstitious beliefs about comets as influenced by their elders. The teachers took the suggestion seriously, and with the video editing software, they explored how they might convince students to look at both perspectives: superstitious and scientific. There were also videos created to explain the parts and functions of an ear, and another on air pressure.

Before we proceeded to the actual layering of media (photos, audio, video) for the production part, several teachers were already considering how and where in their science classes they could possibly apply their new skills in annotating and editing photos, audio, and video using Camtasia and Snagit. As we started arranging the sequence of their media as a storyline, many of them thought of creating videos for their school programs or for birthdays and weddings. Finally, during the post-production part, teachers presented and evaluated their video masterpieces. There was a time constraint when it came to the evaluation portion (for example, some teachers have to leave the session to go back to their classes), and so limited input was given by the teachers.

5.1.3.1 Analyses and Reflections

Ms. I: A Detached and Expanded TPACK

In the context of science teacher-participants, particularly in the specific case of Ms. I, all throughout the eight sessions conducted from January 3–15, 2019, my field notes and memos and teacher-participants' reflections and comments provided rich indications of progress. Ms. I made an initial self-assessment regarding what she felt was her degree of use of TPACK and FoK in her science classes. Her self-assessment is shown in Figure 33. For her, the three circle components have varying sizes depicting roughly how much knowledge she felt she had for every component and how each component was related to one another. Her use of FoK in science, signified by a dotted arrow entering the TPACK's circle, came without any attempt to use any form of ICT, even the chalkboard. It manifested purely in the form of verbal discussion. Thus, she represented her technological knowledge (TK) as detached from other components of TPACK.

Ms. I was a chemistry teacher with a teaching load in earth and general science. She decided to make a 3–5 minute video to convince her students that the comet's appearance is not a bad omen as most of them have heard from their elders. Her plan was to acknowledge students' identities (González, Moll, & Amanti, 2005) by putting together some video clips about superstitious beliefs in comets and anchoring them in canonical science (Taber, 2014).

On her storyboard, she wrote that the popular superstitious belief about comets among elders would be presented. She planned to tell the students through a video that superstitious beliefs are part of their culture. The video clips would present an animation along with some narration about comet sightings recorded in the past. Yet, she would add another clip explaining that comet sightings have been successfully predicted using the laws of physics and mathematics. Ms. I said that she had a considerable background in astronomy. This was supported by her responses on the self-assessment questionnaire, which showed high confidence in content knowledge. However, she admitted that she discusses most of the astronomical concepts in class via a traditional lecture method. This was the reason why she drew a bigger circle for content knowledge than pedagogical knowledge on her pre-production to production self-assessment, as shown in Figure 33.

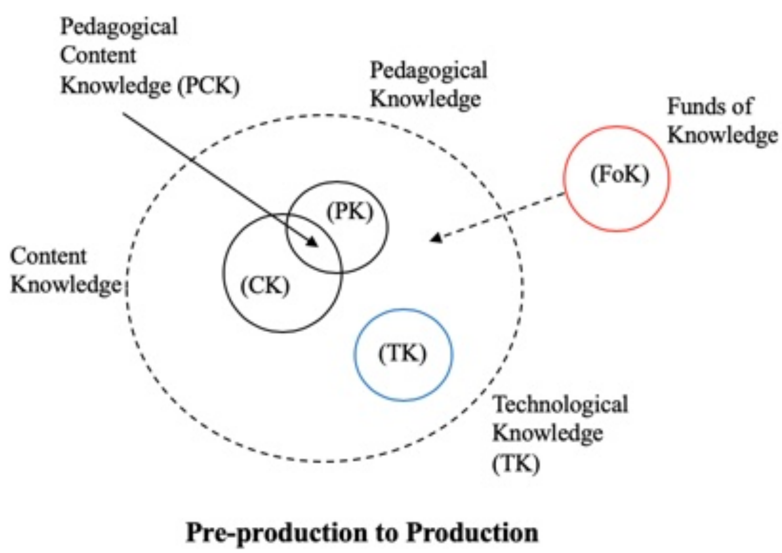


Figure 33: Ms. I.'s TPACK and FoK During Pre-production to Production

Now, she was using Camtasia, Snagit, and some video clips downloaded using the Internet in her home to introduce a comet. Besides having trouble navigating the functions and tools in Camtasia, she had difficulty finding the appropriate video clips. Had she decided to download the clips at her school on the day of the workshop, she definitely could not have stuck to her storyboard. The Internet was so weak that, even in the computer room, we had difficulty opening our email. She might have used still photos instead. Despite her understanding of comets, I noticed that Ms. I tended to use “comet” and “asteroid” interchangeably (in our dialect, a comet or an asteroid is called by the same name: *bulalakaw*).

Moreover, as she described how the comet’s tail is formed as its orbit comes close to the sun, she tended to use “melting” and “dissolving” interchangeably. When a comet’s orbit gets closer to the sun, the part that is facing the sun heats up (to melt and not to dissolve) and disintegrates into dust and gases stretching into space which appear from Earth as a giant bright light (NASA, 2019). This bright light forms the tail of a comet. To melt and to dissolve are two different scientific concepts (Taber, 2005), as are asteroid and comet (Cosmos, 2019). These terms and other similar pairs (e.g., rotation and revolution, mass and weight), when used interchangeably in a science class, might confuse students who are starting to learn the distinct meanings of each term. Likewise, these instances of using distinct terms interchangeably were examples of learning impediments (Taber, 2005).

Through the science video-creation workshops, science teachers were given the opportunity to collaboratively confront learning impediments by differentiating and addressing concepts correctly in their videos. Then, after discussing the distinct meaning of each scientific concept, they brainstormed how they could reorganize and represent the concepts in their storyboards in a way that is accessible for the students. Throughout the workshops, teachers tried to spot possible learning impediments in their storyboards. After spotting them, they discussed how such impediments might have been imparted to their students in the past and how they could correct them moving forward. The discussions did not end there. Teachers tried to recall and examine how learning impediments impact teaching and learning, curriculum and pedagogy in science, etc. The practice of spotting events or circumstances in the teaching and learning process and connecting them to wider issues of curriculum and pedagogy is termed "calling-out" (Frederiksen, 1992) or "noticing" (van Es & Sherin, 2002). From the framework of Learning to Notice (van Es & Sherin, 2002), the act of noticing how the terms are used correctly or incorrectly represents the first level of professional growth. The next level is for the teacher-observer or the "noticer" to be able to connect the learning impediment or learning bug (Taber, 2005) to the bigger perspective of conception and misconception in scientific learning as well as the contextualization of science concepts (Anderson & Nashon, 2006). In the workshops, teachers were able to cultivate the skill of noticing learning impediments by deciding on appropriate labels and annotations in their videos as they considered their students who were learning science as second-language learners (Duff, 2008).

Going back to Ms. I, she completed the production and post-production of her video after the third workshop session. She gradually noticed that she had made considerable improvements. She could already locate several functions and buttons in Camtasia software for annotation, editing, audio control, fade in and fade out of audio, media transition, etc. She said that she needed more time to correctly arrange different photos and illustrations to match with the audio recording or background music. She also reminded herself to consistently attribute all the sources she was using in her video on top of being conscientious regarding the use of animation, narration, and text in combination (Tembrevilla & Milner-Bolotin, 2019). We transferred her video to a portable USB drive and connected it to the wide TV monitor framed by light steel bars to protect it from scratches. During the brief discussion and evaluation of her presentation before her fellow workshop participants, Ms. I started to notice how she restrained herself from the use of the term dissolving vs. melting as she again explained how the icy parts of a comet disintegrate as the comet gets closer to the sun. She noticed that she was still using "comet" and "asteroid" interchangeably, as she was confused by the translation of the term *bulalakaw* (both meant as comet and asteroid). "Should you use more animation with audio or music background?" one teacher-participant asked her. She replied, "I am not sure, but if I were watching the video, I think I need to explain the concepts correctly and clearly."

In our (me and my supervisor at the University of British Columbia) experience making science videos for science, technology, engineering, and math teachers (STEM), we make sure that the concepts are explained clearly. We explain the concepts in the language understood by our target audience. We also limit the combination of narration, animation, and on-screen text to reduce cognitive load for the viewers (Tembrevilla & Milner-Bolotin, 2019) as empirically studied and recommended by Mayer (2017).

The short evaluation provided Ms. I some avenues to reflect on the relevance and appropriateness of her video for her students, the improvement of her TPACK, and her use of FoK. She admitted, however, that the whole process of making the video was indeed time-consuming. Similar to the rest of the teacher-participants, Ms. I said that her clerical, administrative, and teaching loads were becoming more overwhelming. She said that she would probably not have enough time to finish the video had it been done during a regular class day. Based on Ms. I's self-reflection, she changed her TPACK and FoK diagram as shown in Figure 34. She narrated that her improved understanding and awareness of scientific concepts like melting, dissolving, comet, and asteroid allowed her to adjust the sequence of her video clips. She adjusted the order of the video clips, and added pictures of a grandmother telling a story to her grandchildren about a comet and a scientist illustrating how the tail of a comet is formed. She added these pictures as she invited students to recall the stories they had heard from their elders and science teachers about comets. By presenting both sides of the story—both the superstitious and scientific—Ms. I felt she maintained the proper balance: “Elders’ wisdom was acknowledged. The scientific perspective was introduced. Now, the students can start a discussion with one another.”

Ms. I’s post-production TPACK has positively and gradually changed. The circle representing technological knowledge has now overlapped with content and pedagogical knowledge (Figure 34). The circle representing pedagogical knowledge has increased in size as well as the circle on technological knowledge. The FoK’s arrow entering and pointing to the overlapping circles of TPACK components indicated that FoK was integrated in the video-creation. The increase in the size of circles related to PK, CK, and TK and the re-connection of TPACK’s three components were indicators that integrating FoK with the use of ICT enhanced Ms. I’s TPACK.

One observation that stands out in the video-creation workshops, as represented by Ms. I, was that the FoK expanded the original TPACK framework. Prior to this and for the first time, her pre-production TPACK (Figure 33) indicated that a detached TPACK can exist in junior high school science teaching with FoK. Notably, for the first time as well, her post-production TPACK (Figure 34) revealed that a teacher’s TPACK can also be expanded not by any component from the inside of the framework but by an outside component. The science video-creation with the use of FoK not only expanded each of the TPACK components but also allowed each component to be reconnected to one another. This is seen as a novel idea for the TPACK framework, since the original framework was intended to portray a “state of dynamic equilibrium” of the three components only: technology, pedagogy, and content (Mishra & Koehler, 2006, p. 1029). Ms. I’s pre-production TPACK separates the technological knowledge component from the other two components. In the context of actual teaching, this situation denotes that science teaching without appropriate educational technology integration does not produce quality science teaching as suggested by the TPACK framework. However, her post-production TPACK represents an expanded TPACK. An expanded TPACK brought about by the use of technology and FoK denotes a science teaching innovation that potentially improves the quality of science teaching as it aligns with TPACK’s framework.

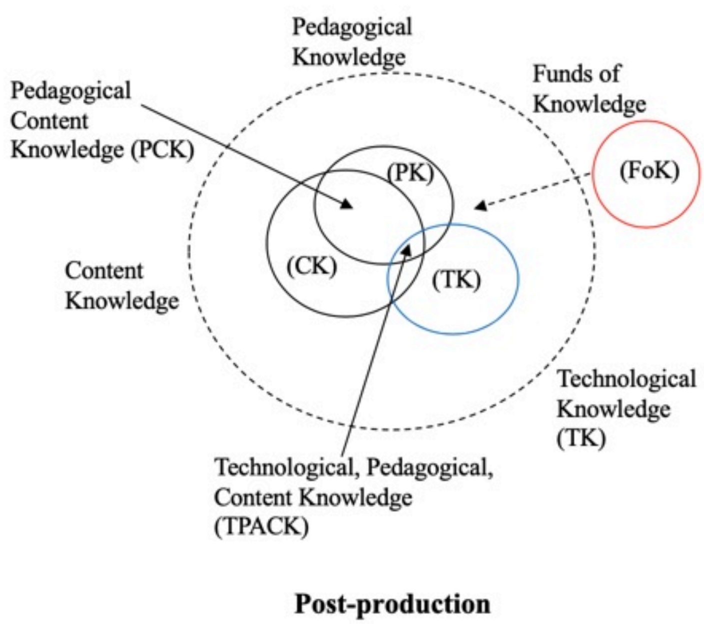


Figure 34: Ms. I.’s TPACK and FoK During Post-production

Ms. C: The Translator and Interpreter

Unlike Ms. I., Ms. C. had been using videos for her science class for the past two years. She usually downloads YouTube videos about weather, earthquakes, and sci-fi movies. Her consistent complaint was that when she showed these videos to the class, she literally translated the discussion from English to Hiligaynon (the local Philippine dialect) for the students to understand. She said students are not used to catching-up with the fast and difficult to follow British or English accent. With the translation, students can pick up the concepts in the video, yet Ms. C tended to need to extend the lesson into another session or send the students late to their next class. Ms. C explained how the showing of videos in class attracted students' attention:

> Sometimes I needed to move forward the movie clip because I was running out of time but the students would scream 'No!'…because they still wanted to see all the parts of the video. Now I have two problems. One was how and where to look for videos with less British or English accent. Second, I needed a wide screen or TV monitor.

I had a one-on-one science video workshop with Ms. C for two hours. She knew how to use Word, Excel, and PowerPoint. She had some experience downloading and doing quick movie editing using a pre-arranged video maker. What she liked about Camtasia and Snagit was that she could record the explanations of science concepts and details of the video in dialect with her own voice. Based on her own self-assessment and impressions after the workshop together with further reflections which she sent to me via email two months later, she said, "I am happy that I am making videos with my voice as the explainer and interpreter in the background…they were giggling as they listened to my voice."

Ms. C said that without having to constantly translate videos from British accent to dialect, she had much more time with her students to discuss the content of the video in relation to their experiences. She added that while surfing online to look for content for her video, she was able to encounter new ideas and techniques to help her teach science. Although there are plenty of teaching ideas online, she was becoming more discerning in choosing appropriate sources for her videos. Ms. C was growing as a critical user of online resources. She was starting to realize science videos online do not completely address the actual needs of her students. Now that she knew how to edit and split video segments, she had the liberty to include or exclude a given video segment for her own science videos. She also realized that while the use of science videos offers an easy way to communicate scientific concepts to the students, it does not replace the practice of communicating and discussing concepts face-to-face with her students in a classroom or video call. It was an indication of her professional growth as media literate (Choe, 2017) and a critical user of technology for her science class (Koehler & Mishra, 2009).

Ms. C.'s interview transcripts were punctuated with interjections like "Yes," "Ok," and "Oh I see…" and I understood the reason. My memo notes indicated that during the interview, her explanations were offered, most of the time, through gestures or drawings. The recordings of "Yes," "Ok," and "Oh I see…" recalled to me our animated discussions, which were similar to my conversations with the most of science teachers I interviewed and spoke with during and after the video workshops. The animated sharing of ideas by Ms. C. during the interview was an indication that the interview process was not just a standard protocol of question and answer. Rather, it was a mutual conversation and social practice where I and Ms. C. were co-contributors of knowledge (Talmy, 2010).

Summary of the Key Findings

Through a thematic analysis of all interview and focus group transcripts including the pre- and post-science video-creation workshops, the following key findings were identified:

(1) Four emergent themes became clear. These themes were: enablers, policy and governance, affordance of available technology, and FoK.

(2) Enablers were science teachers' actions, activities, and practices that described their key initiatives to integrate ICT in their science classes despite limited resources and support.

(3) Policy and governance involved three sub-themes: PD, budgetary constraints, and competitiveness with private education. These sub-themes pertained to directives and ICT initiatives from the government and perspectives of science teachers on PD programs related to the use of ICT. For the science teacher-participants, the focus on policy and governance should be about how national ICT initiatives should be re-calibrated and re-purposed to suit the actual needs of science teachers in rural school settings

(4) Affordance of available technology included three sub-themes: technology, multimedia literacy, and closing the digital divide. Considering the limited technological infrastructures in rural schools, for the teachers, affordances of technology referred to "appropriate ICT resources" rather than "available ICT resources." Appropriateness meant that DepEd leadership should invest in ICT and teacher PD that match with the existing facilities in their rural schools. Science teachers like Ms. I were able to start recognizing the affordances and constraints of educational technology (e.g., video).

(5) FoK was defined as having two components: community collaboration and parent teacher engagement. FoK was seen as a bridge to promote valuing of students' and communities' history and practices while developing students' science literacy and reasoning.

(6) With FoK integration, a detached TPACK and an expanded TPACK were documented for the first time in rural junior high school science teaching. A detached TPACK might reduce the quality of science teaching, but an expanded and re-connected TPACK introduces innovative new science teaching with FoK and technology in rural schools.

Chapter 6: Results and Discussions

In this chapter, I discuss the three overarching themes generated after the triangulation of quantitative and qualitative data analyses and findings. I start by recalling the summary of quantitative and qualitative analyses outlined in Table 21.

Quantitative Analysis	Qualitative Analysis
Profiles of Participants & Division-Region Wide Trends • 141 public junior high school science teachers joined all over DepEd Region 6 • 39 out of 45 science teachers from the Division of Bago City, the research site, joined; they represented 87% of the total junior high science teachers in the division • 122 of the science teacher-participants were in their 1st-3rd year of teaching • 81% were bachelor of education graduates • 76% were master's degree holders • 96% have laptops, 73% used Internet for science class from personal subscription, 81% complained of no or slow Internet, 75% used laptop mostly for video and power point showing • Top 3 FoK themes used by teachers: local geography, agriculture, & elders' beliefs **Emergent Themes** • EFA yielded three emergent themes: TPACK, Administrative Support & Professional Development, and FoK • The three themes were determined using multiple statistical analyses: Kaiser's (1960) eigenvalue-greater-than-one-rule, Maximum Likelihood, Principal Axis Factoring, Catell's (1960) Scree Test, Velicer's (1976, 1986) Minimum Average Partial Test, and Horn's Parallel Analysis • Prior to EFA, data were tested for EFA suitability. Kaiser-Meyer-Olkin value was at 0.712 (higher suitability) and Bartlett's Test of Sphericity at $p<0.001$ (highly significant suitability)	**Emergent Themes** • Four emergent themes were generated out of the 20 individual themes. • The four themes include: Enablers, FoK, Policy & Governance, and Affordances of available technology. • **Enabler** The challenges teachers faced as they use ICT like inequality and limited resources, limited content and pedagogy for science subjects taught outside their expertise enable them to become resourceful and creative, self-sacrificing, resilient, open and less reluctance for change. • **FoK** Use of FoK in science classes bridged respect among students, school, and community. It develops science literacy and argumentation. However, it was also seen as a threat to the development of the same, science literacy and argumentation, when students have high regards with their elders' superstitious beliefs. Use of video had the potential to balance the two. • **Policy and Governance** ICT investments should focus on teaching and professional development of teachers. Teachers suggested that ICT investments should match the existing infrastructure of the school and their actual needs. • **Affordances of available technology** ICT investments should focus on improving teachers' PCK. "Appropriate technology" was better than "available technology". ICT should be based on teachers' needs and existing infrastructure in school. • For the first time, a detached TPACK and an expanded TPACK were documented when FoK was integrated in science class in rural high school.

Table 22: Summary of Quantitative and Qualitative Analyses

6.1 Results: Overarching Themes

The mixed-methods model (Johnson & Onwuegbuzie, 2004) adopted in this study is a combination of quantitative and qualitative methods and a toolbox to establish overarching themes and link the strengths of my quantitative and qualitative analyses. It offered me the option "to mix and match design components that offer the best chance of answering [my] specific research questions" (Johnson & Onwuegbuzie, 2004, p. l5). It is an integrative method that permitted me to gain a wider perspective on the challenges faced by science teachers as they use ICT in their class as the phenomena in focus (Watkins & Gioia, 2015).

Now, using the "core premise of triangulation," that is, finding the convergence and corroborations of mixed-method results looking at the same phenomena (Greene, Carcelli, & Graham, 1989, p. 256), I present three overarching themes as findings of this study:

1. **TPACK as a foundational professional development enabler of ICT-centered curriculum implementation.**
2. **FoK as a bridge to enhance teachers' TPACK and ICT-centered science pedagogy.**
3. **Successful implementations of ICT-centered science curriculum and pedagogy as policy and governance dependent.**

6.1.1 Theme 1: TPACK as a Foundational Professional Development Enabler of ICT-centered Curricular Implementation and a K-12 Enabler

Based on EFA, question items 16–21 (Table 18) in an online questionnaire merged into one factor, and that factor was conceptually interpreted as one emergent theme: TPACK as a new K-

12 curriculum enabler. The five items represented the highest factor loading mean at 0.806. These five items that belonged to TPACK as a theme were named technology, pedagogy, content, confidence, and beliefs and attitudes. These themes matched with the themes coded using qualitative methods. Based on thematic analysis, individual codes that aligned with TPACK and enabler themes were substantially referenced and attributed to one-on-one and focus group interview transcripts and science video workshops including field and memo notes. NVivo analysis traced these themes with a corresponding number of references as follow: enabler (60), resourcefulness and creativity (60), affordances of available technology (58), pedagogy (41), content (37), technology (31), professional development (22), and multimedia literacy (17).

In the context of DepEd's new K-12 curriculum in junior high school science, TPACK becomes a foundational part of professional development. It means mastery of content and diverse pedagogical approaches including ICT competency to teach core science subjects both inside and outside teacher-participants' expertise. This aligns with similar research among public and rural junior high school chemistry teachers in the Philippines (Orbe, Espinosa, & Datukan, 2018). In this study, chemistry teachers noted that since science subjects (e.g., biology, chemistry, physics) are specialized subjects, teachers should also have specialized training in biology and physics coupled with ICT training in order for them to be competent in teaching such core science subjects. To be a specialist in one subject takes time, and to be a multi-specialist in the new curriculum takes a lifetime. This finding further supports the need to improve Filipino teachers' mastery of their content subjects as reports showed that elementary and high school teachers' subject content knowledge was low on top of unsatisfactory professional development training (Oxford BG, 2017).

Teaching science in rural schools demands craftmanship and creativity. Struggles to master content among teacher-participants were evidently observed during science video workshops. For example, Ms. I was aware that she used the terms “comet” and “asteroid” interchangeably as well as “melts” and “dissolves.” Teacher-participants’ difficulty in creating storyboards in a way that considered students’ needs and realities was also an indication that they are striving to improve their pedagogical skills, as seen with Ms. K. Ms. A added that with limited teaching resources in public schools, everything boils down to what she calls *diskarte* (teacher’s craftmanship and strategy). If the teacher knows how to use *diskarte* and is really interested to helping students learn in her class, “she will have several ways to teach the lesson.” In education research, Shulman (1987) calls this transformation. One indicator of transformation— according to Shulman’s enduring classic pedagogical and content knowledge (PCK) legacy—with which teacher-participants are struggling is the ability to design a lesson that matches their students’ actual needs, language, motivations, etc.

Ms. A’s teaching craftmanship equates to her ability to address students’ learning difficulties by modifying her teaching styles. It is a manifestation of her progress in mastering content. For Ms. I and Ms. K, making use of video in science class by personally creating storyboards, layering media, and annotating was a total transformation of their formerly fixed understanding of the functionality of a video. Particularly in rural settings where you literally need to climb a tree or elevate yourself to send short messages from a mobile phone, teachers understood that science videos are intended for students to watch and learn scientific concepts. Prior to the workshop sessions, they never realized that video editing technology was accessible and they could make their own science videos with a backdrop of hectares of sugar cane and rice paddies. Now, they can create their own videos and in the process expand their TPACK. Rural high school science teachers' experience of overcoming fixation on what a particular technology's function is (e.g., video) and exploring more creative ways that such technology can function to improve teaching and learning practice is a distinct indicator of professional growth. For rural schools that are dismally sideswiped by progress and development, science teachers are now the enablers who decide how available technology will and should function to serve the curriculum. Cognitive scientists have a term for teachers' experience of fixation regarding a technology's function: "functional fixedness" (Birch, 1945; German & Barett, 2005). Functional fixedness impedes inquiry and exploratory ways of using technologies creatively (Koehler & Mishra, 2008). Teachers' ways of exploring creative uses of available technology beyond their "functional fixedness" to address curricular and pedagogical needs of rural schools stands as a resounding TPACK enabler.

Science teachers' desire to master science domain subjects in junior high school, which both themselves and the school have to work out, is clearly mandated by Republic Act 10533 known as the "Enhanced Basic Education Act of 2013" and popularly termed as the new K-12 curriculum (RA, 2013). It states that teachers should provide every student "an opportunity to receive quality education that is globally competitive based on a pedagogically sound curriculum that is at par with international standards" (p. 2).

Another concrete example of how science teacher's growth in TPACK enables enhanced teaching and learning in rural schools was exhibited by Ms. C. Prior to the science video workshops, she complained that every time she showed a science video to the class, she had to literally translate the discussion from English to Hiligaynon (local dialect) since students had difficulty following a British or English accent. Now, she can record her voice explaining the differences between the epicenter and the focus of earthquake. Ms. C is becoming adept at modulating her recorded voice using Camtasia and Snagit. With this software, she can create videos using her voice as a background translator of science concepts. Because students could understand the new science videos, Ms. C can save some instruction time that she can use for more discussions and activities in a 60-minute class. In Mayer's (2004) multimedia learning theory, Ms. C's technique of recording her voice to explain scientific concepts in her videos is related to the principle of personalization—having a human element that enhances the process of meaning-making for the audience. Ms. C's recorded voice might increase students' attention and participation when watching videos, since personalization builds familiarity and emotional association with the students (Hansch et al., 2015).

TPACK as a foundational professional development enabler of ICT-centered curriculum also involves science teachers' beliefs and attitudes about ICT and their impact on pedagogy. Their pedagogical beliefs and appreciation of ICT were shown in their creativity, resourcefulness, and self-sacrifice. They initiated fund-raising activities to purchase an LED TV for their science classes. They provided themselves with laptops that they can use for audio-visual presentations in class, besides using them to store and manage students' records. They agreed to switch classrooms in the middle of class to share the use of a single LED TV when colleagues need to use it as well. They provided students with portable USB drives for enrichment activities where students can access the Internet on their own outside the school. They bought a second-hand copier for paid photocopying services among teachers, students, and staff and then used the proceeds to buy laboratory equipment. They took turns adding Internet data on their pocket Wi-fi to access the Internet during their science classes. They were going the extra mile despite the limited availability of ICT infrastructure and resources. Studies have revealed that higher frequency of ICT use in the classroom is closely linked to teachers' positive beliefs and attitudes towards ICT (Jimoyiannis & Komis, 2007; Mama & Hennessy, 2014; Milner-Bolotin, 2017). These are very encouraging indicators that teacher-participants have a strong belief that technology can support equity in learning, particularly with students in rural areas who generally have less access to technology than their counterparts in urban areas (Vergel de Dios, 2016; Business World, 2018; Ramos, 2019).

Lastly, teacher-participants' efforts to integrate ICT in the new K-12 science curriculum despite limited resources transformed them into new K-12 enablers in the rural areas. Nearly all of the indicators of teacher-participants as enablers surfaced in qualitative data analysis. In fact, except for "enabler" as an additional emergent theme under qualitative data analysis, both quantitative and qualitative analysis reached parallel convergence on three generated emergent themes: TPACK, FoK, and Policy and Governance. Had coding references attributed to "enabler" as a theme in qualitative analysis failed to reach 50% of the total references originating from one-on-one interviews, focus group discussions, observations and reflections during science video workshops, it should have been dropped from the final list of emerging themes. However, as shown in qualitative analysis, "enabler" occupied the topmost level of emerging themes. Framed through a TPACK lens, teachers' struggles to integrate technology are complicated as they start to understand that technology, besides being limited in availability in rural schools, has specific affordances and constraints. Yet the enabling practices of science teacher-participants listed below indicated that their subject content knowledge is expanding and they made it accessible to the students by:

(1) contacting former students, alumni, and parent-teacher associations for donations to purchase LED TVs and other needed classroom renovations (e.g., classroom toilet, floors, or windows);

(2) inviting resource persons in the community to talk in their science classes (e.g., farmers, poultry owners);

(3) using local and native fruits and plants as models for body organs;

(4) using local tools and practices in farming;

(5) printing activity materials in advance at home for each group of students in the class;

(6) using empty condiment bottles as improvised beakers and test tubes;

(7) bringing local plants and fruits into the class to test them as either acids and bases, etc.

On top of these practices, Ms. B and her other six colleagues in one school's science department opted to stay together in a makeshift faculty room extended off the end of a regular classroom. Ms. B clarified that by doing this they can conveniently exchange ideas, share teaching practices, and do things together that can improve camaraderie and interpersonal relationships. The struggles of teachers to understand the affordances and constraints of technology and their enabling practices including Ms B's and her colleagues' choice to gather in a makeshift faculty room echo what research says about teachers' traits that constitute expertise in teaching. Quoting Campbell (1990-1991), Smith and Strahan (2004) said that expert teachers persistently seek to improve their practice, and "outstanding teachers adapt to professionally inadequate environments by continually seeking avenues to improve their teaching performance and by seeking and maintaining peer support systems that reinforced their sense of mission" (p. 368).

6.1.2 Theme 2: FoK as a Bridge to Enhance Teachers' TPACK and ICT-centered Science Pedagogy

Use of local knowledge in science education improves student science literacy.

Ms. H (Transcript 10/10, Dec. 7, 2018)

Besides the encompassing references attributed to the theme "enabler" and individual child nodes that connect with TPACK as a theme, FoK also frequently manifested in teacher-participants' interview transcripts and in my recorded memos and field notes during science video workshops. The online questionnaire revealed three foremost topics under FoK that teachers heavily used in science: local geography, agriculture, and elders' beliefs. Teacher-participants' initiatives to use FoK in science instruction as discussed in detail in Chapter 5 started way before the K-12 curriculum (RA, 2013) was introduced. However, the new curriculum is explicit in stating that "the curriculum shall be flexible enough to enable and allow schools to localize, indigenize and enhance the same based on their respective educational and social contexts" (p. 4).

The rural schools where junior high science teacher-participants work are potential sites to bridge science with the culture of the local community. With the vastness of rice fields, root crops, and vegetable gardens in the rural areas of the city, Ms. G provided opportunities for students to debate on topics such as the advantages and disadvantages of the use of organic and inorganic fertilizers. She enriched these debates by inviting local rice farmers to talk in her class.

In her class, Ms. A used earthquake data from nearby provinces in regions hit by earthquakes in the past for her students to master the skill of locating earthquakes using triangulation analysis. The majestic Mt. Kanlaon, the Bago River, and the yearly fiesta and festivities of the city and province offer rich connections for teachers teaching earth and general science subjects. In classifying volcanoes as a topic in earth science, Ms. H brought her class just outside their classroom, asked them to sit on the grass, and invited them to gaze at the grandiose shape of Mt. Kanlaon; she then let them recall stories from their elders about the volcano's past eruptions. From there, she led students to classify popular volcanoes in the region as active, dormant, or extinct. For Ms. H, "localization in science education is science literacy."

At another school, Ms. F found that when science concepts are conceptualized vis-à-vis her students' realities, "the pacing of discussion is smooth and fast. You can touch more issues and topics related to one science concept because they can make connections." Ms. F noted that when the class understands the discussion, students raise more specific questions and this circumstance provides opportunities for other students to join in and agree or disagree with what's being said. In the works of Kelly and Chen (1999), Lemke (1990), and Mason (1996), Ms. F's students' discussion appears to be an instance of "science learning in terms of the appropriation of community practices that promote the modes of communication required to sustain scientific discourse" (as cited in Erduran et al., 2007, p. 4). Moreover, in their book on argumentation in science education, Erduran et al. (2007) underscore the "importance of discourse" similar to that of Ms. G's class with their debates on the use of organic and inorganic fertilizer or Ms. A's class with their triangulation of earthquakes as platforms in the "construction of knowledge" (p. 4). However, the dynamic and animated discussions in Ms. A's class (triangulating earthquakes), Ms. H's class (identifying types of volcanoes), Ms. K's class (watching movies with their teacher as the narrator), and Ms. G's class (debating the merits of organic and inorganic fertilizers) were absent in Ms. I's class, though she also used students' FoK. In her class, Ms. I asked her students about their ideas on comets. Students were quick enough to confidently cite their elders; yet when the teacher quizzed them on the scientific explanation for the occurrence of a comet, all she got was a deafening silence in the room. According to her, the students were not even listening when she verbally provided the answers to her own question. Based on the online questionnaire, elders' beliefs as FoK constituted the third most common FoK topic that teacher-participants used in their science classes (Figure 16). When students stood by their elders' explanations about comets, it reinforced a common tradition among us Filipinos (and many other cultures)—that is, a deep respect for elders. This supports what Ingersoll-Dayton and Saengtienchai (1999) found: that despite variations in education and modernization in the Philippines, Singapore, Taiwan, and Thailand, respect for elders is "built into the social fabric of most Asian countries" (p. 113). This is also indicative of social relationships (Ho, 1982) and hierarchy in the family (Limanonda, 1995). This is significantly relevant in Filipino culture, where superstitious beliefs abound in all aspects of people's lives (Cabie, 1974).

We Filipinos believe in spirits, and my grandparents warned me that they can make a person sick or drive him insane. In our region, where all the teacher-participants reside, there has been a radio program running for years now that talks about *Aswang*, or evil spirits. My mother once said that *Aswang* can suck the blood of a sleeping person in the middle of the night by thrusting their long tongues through the roof of a house. To return to the dilemma of Ms. I, this teacher identified a solution she could use the next time the discussion of comet comes around—namely to show some diagrams or videos that show comets appearing and disappearing in the sky. Ms. I's reservations regarding the use of FoK in science class resonated with the concerns of some other teacher-participants:

> FoK bridges respect between school and community. It enhances my PCK and students' science literacy and reasoning. However, students' respect with their elders limits their understanding of scientific phenomena.

In Ms. I's case, her use of FoK along with Camtasia and Snagit software in the science video workshop indicated an increase in her self-assessed TPACK competencies (Figures 33–34). A similar observation can be made in Ms. C's case, as Camtasia and Snagit facilitated the audio recording of her voice as a replacement for narrators with British and American accents. Specifically, using Taber's (2005) "teacher-as-learning-doctors" and van Es and Sherin's (2002) "Learning to Notice" frameworks, Ms. I started to question how appropriately she uses scientific terms in her video (e.g., melt vs. dissolve, comet vs. asteroid). Although she had difficulty arranging her storyboard, she was becoming aware that the more she explores different teaching strategies to help her students learn, the more she knows her students. She also believed that when she showed the completed video to her class, the students might be challenged to examine their elders' beliefs regarding the appearance of comets and why comets have tails from a scientific perspective. Ms. I's video on comets might "spark curiosity" among her students. However, more than igniting students' curiosity, Ms. I hypothesized that integrating FoK in science should lead students to balance scientific and non-scientific conceptions. Igniting students' curiosity through a video by "making the familiar unfamiliar and challenging misconceptions” (Choe, 2017, p. 11) further enhances teachers’ TPACK and represents as concrete response to the challenge of a new ICT-centered science pedagogy. The use of FoK without any educational technology in this study, for the first time, recorded a detached TPACK, while the use of FoK and technology through video creation for a science class, also for the first time, proved that TPACK components can be re-connected and expanded. The integration of FoK and use of technology also led teachers to become consciously aware of the affordances and constraints of technology (e.g., video).

Teacher-participants believed that using FoK in the long run will help students value the mutual presence of science and culture in every community, and especially to value the people in their community. Valuing the richness of community and the people in it is in fact seen in Chevallard’s (1991) framework as a way of acknowledging that knowledge resides and lives within groups of people. It was also the cornerstone of Gonzalez et al.’s (2005) book on FoK. For these authors, “People are competent, they have knowledge, and their life experiences have given them that knowledge” (p. ix-x). Similar to the teacher-participants’ observations that the use of FoK facilitates mutual respect and understanding between them and the students, Gonzalez et al. (2005) signified that valuing the richness of what people have generates *confianza* or mutual respect.

While there is a significant body of research in the Philippines on the relevance of cultural practices in the community vis-à-vis science education for preservice science teachers (Arellano, Barcenal, Bilbao, Castellano, Nichols, & Tippins, 2001; Handa, 2008; Handa, Tippins, Thomson, Bilbao, Morano, Hallar, & Miller, 2008; Tippins & Handa, 2010; Handa & Tippins, 2011, 2013), research on how Filipino practicing science teachers make use of FoK in their classes in the context of the new K-12 science curriculum appears to be limited as Morales (2016) recommended a series of programs integrating Filipino culture and language in science teaching.

6.1.3 Theme 3: Successful Implementation of ICT-centered Science Curriculum and Pedagogy as Policy and Governance Dependent.

> *The technology I used in my science and physics class is just a tool that would bridge learning between me and them. I just wish that ICT investments in public schools should focus on teachers' professional training more than delivering computers and gadgets in schools for students.*
>
> Ms. A (Transcript 23/34, Dec. 12, 2018)

In quantitative analysis using EFA, nine items from the questionnaire (Q5–Q13) merged into one factor (Figure 21) and appeared as an emergent theme. These items revolved around four themes: professional development, policy, administrative support, and availability of resources. These four themes were conceptually combined and interpreted as administrative support and professional development. In qualitative analysis using thematic analysis, there were two emergent themes (Figure 23) that converged with EFA. These two themes were affordances of available technology, and policy and governance. By reviewing and re-tracing individual child nodes under these two emergent themes from thematic analysis and looking into the emergent theme resulting from the merging of question numbers Q5–Q13 in EFA, I came up with the third overarching theme positioning policy and governance as critical factor in the successful implementation of ICT-centered science curriculum and pedagogy.

Based on qualitative analysis, this overarching theme was heavily sourced from teacher-participants' comments on how ICT investments should be advanced for their professional development. The discussions as presented in Chapter 4 concentrated not on “available ICT resources” but rather on “appropriate ICT resources” in schools that can be maximized for students’ learning and teachers’ professional growth. According to the teachers, “appropriateness” meant ICT investments should concentrate on improving their PCK, especially related to science subjects they are assigned to teach outside their expertise. It also meant ICTs should be appropriate in their current school’s physical infrastructure. They could not maximize the computers available if there is no Internet connection in their school. For example, Ms. A opted for an LED TV instead of an air conditioning unit as a gift from her former students. With the monitor fixed on the wall permanently, she has more time and energy to spend on important instructional tasks such as reviewing her PowerPoint slides. Some of her colleagues at school, seeing the comfort and benefits of the LED TV monitor compared to a projector lamp, are gradually following her practice.

In the case of Ms. K, instead of showing science video clips with a British or English presenter to her students, she has now the option to record her voice using Camtasia. Since her students would understand her voice better than that of foreign language speakers in the video, she expects she will save time explaining the contents of the video and be able to focus more on critical discussions of the content of the video, thus better engaging students and enabling them to learn more. In the case of Ms. B, in order to compensate for limited textbooks, she can now use Camtasia and Snagit to make screenshots of textbook pages before annotating and showing them to her class using her laptop. She can do this by either asking her class to gather around her table for everyone to see the laptop or projecting the images on an LED TV. However, unlike in Ms. A’s classroom where a fixed TV monitor is mounted on the wall, Ms. B has to arrange with her other six fellow science teachers to switch classrooms to share the TV unit. In order not to lose much instructional time as they change classrooms in the middle of class, students were given reflection or guide questions. Similar to the other teachers in the rest of the eight schools I visited, in Ms. B's school, teachers have to download online resources in advance at home, since Internet for classroom use is not available except in the school's computer learning resource room. In some schools, the Internet slows down with a higher number of users straining the minimum Internet capacity of the school's server.

With the current infrastructure in these schools, what science teachers need most is content and pedagogy training, a comfortable science teachers' room with quality reference textbooks, and laboratory equipment. DepEd has on-going computerization programs delivering ICT packages in public schools (DepEd, 2019); however, with the lack of Internet access, unstable power supply, limited ICT training programs for teachers, and demanding teaching loads, computers might not be maximized for learning.

As a matter of fact, DepEd acknowledged that even if they have the budget for Internet, it would be useless for schools in rural and remote areas where Internet providers are not present (Arayata, 2017). This apprehension echoes the World Bank report (2017) which cites studies that many of the ICT interventions in education "fail or stumble badly before being implemented" (p. 146). The weak and minimal infrastructure in the likes of Ms B's school, such as limited access to electricity or Internet connection, has minimal capability to advance computerization programs. Government departments and agencies aiming for highly visible investments may miss learning in the classroom since new investments do not consider the current realities of the school system. In addition, there may be issues with school administrators who are unrealistically optimistic regarding the transformative impact of technology in schools (World Bank, 2017).

Teacher-participants' comments on the appropriateness of ICT that should be used in their science and physics classes also aligns with the World Bank Development Report (2017), which cautions developing nations regarding ICT investments in education. According to this report, "Technological interventions increase learning only if they enhance the teacher-learner relationship" (World Bank, 2017, p. 145). For example, computer-based software in Qinghai, China allowed students to learn at their own pace and adapted to their knowledge of mathematics (Lai, et al., 2012). In contrast, increasing the availability of instructional materials in schools does not boost learning if the materials do not bridge teacher-learner engagement (World Bank, p. 148). For example, as cited earlier, Sabarwal et al. (2014) noted that giving more textbooks in Sierra Leone in 2008 did not provide more interaction for students and teachers "because administrators put most of the books in storage—potentially to hedge against future textbook shortfalls" (as cited by World Bank, 2017, p. 148).

In a separate study by Barrera-Osorio and Linden (2009), an increase in the provision of desktop computers to classrooms in Colombia did not impact students' learning since they were not well integrated in the curriculum. Thus, Behar and Mishra (2018) argued that one of the most effective uses of technology to attain educational outcomes lies not in getting the technology into the hands of the learners in the classroom, but rather in maximizing ICT's potential related to the professional development of teachers.

As regards the foregrounding of this study on the interplay between DepEd and DICT leadership involved in the wider implementation of ICT policies and initiatives in education, teacher-participants' discussion did not heavily involve any national issues such as the transition of DICT, the changes in DepEd leadership, any specific national ICT initiatives, or stakeholders and donors. The most common theme that kept resurfacing during science video workshops and informal conversations during snacks and lunch breaks was government ICT investments in education that should be geared further toward teachers' professional development.

Another issue that resounded among teacher-participants was how DepEd systems and policies aligning with local school management could reduce some of teachers' administrative and clerical workload (Hernando-Malipot, 2018a; Tomacruz, 2018) and allow them to concentrate more on teaching and learning aspects. An inquiry made by the Philippine Institute for Development Studies, a state think tank focusing on research for planning and policy advocacies, noted that DepEd should re-examine the workload of teachers to improve the delivery of quality education in public schools (Tomacruz, 2018; Leyco, 2019). Studying secondary English teachers in Australia, Manuel, Carter, and Dutton (2018) described that increasing the workload of teachers was "perceived to be the single most determinant factor in impeding English teachers' desire to focus on the 'core business' of teaching to their best" (p. 5). McGrath-Champ et al. (2018) further stated that increased administrative workloads are seen as a "blanketing" effect cutting across "all types of schools, locations, levels of socio-economic advantage … and severely threaten to overwhelm teachers' professional focus on teaching and student learning" (p. 2).

The issues of teachers' workloads and how school level management addresses teachers' concerns are parallel to studies published by the World Bank (2017) noting that assurances of government and school management reforms along with community participation can achieve more learning only if they enhance interaction between teachers and learners. Bloom et al. (2015) observed that well-managed schools produce better student test results. Different schools have different management styles and qualities. School performance is attributed to effective school leadership (Robinson et al., 2008; Waters et al., 2003). School principals with effective leadership styles are actively involved in engaging with teachers to address school-related issues such as instruction, setting goals and priorities, lesson planning, assessments, classroom observations, etc. (Bloom et al., 2015).

6.2 Limitations of the Study

The findings of the study are restricted to science teacher-participants and data collection tools employed in one region of the Philippines. Similarly, the length of my time with the teachers, types and amount of data gathered and the frameworks and the type of analysis used resulted from the juxtaposition of my identity as an insider, outsider, and space in-between in relation to all my teacher-participants in all the schools I visited as discussed on section 3.5.2.

The responses from the online questionnaires from science teachers across DepEd Region VI, Western Visayas were a self-assessed instrument. Consequent analysis and conclusions are dependent on the accuracy of the responses. Most of the science teachers complained about Internet speed and access while they were answering the online questionnaire. Some questions and portions of the questionnaire were unrecognizable. If not for this issue, the total number of responses could have resulted in a much higher count than 141.

Due to time constraints and the administrative nature of the work of science school division supervisors, superintendents, and regional directors, their scheduled interviews were cancelled.

Moreover, science teachers were showing significant improvements relating to an improved TPACK and FoK through science video creations. However, future research will need to examine how video creations could be translated into engaged teaching and learning practices in the classroom.

Chapter 7: Conclusions and Implications

This section begins with the discussion of answers to each research question raised in the beginning of this study and ends with the conclusions and implications of the study.

7.1 Answer to Research Question 1

> What are the experiences, including key challenges encountered by rural junior high school science teachers, during integration of ICT in their science teaching within Philippine public high schools?

First, as seen from the combination of the three overarching themes—one (TPACK), two (FoK), and three (policy and governance)—junior high school teacher-participants are faced with a daunting task of mastering other core science subjects along with corresponding pedagogical techniques outside their subject expertise. This issue stemmed from DepEd's new K-12 science curriculum (RA, 2013), where the content of core science subjects (earth and general science, biology, chemistry, and physics) is being taught at the public junior high school level on a per quarter basis. This is a spiral progression approach (SEAMEO, 2012) where the basic content in a given core science subject are taught in Grade 7 and more complicated concepts introduced spirally in Grades 8, 9, and 10. Each core science subject is a specialized field. However, science teachers were trained in only one core science subject. This issue of incongruence, of assigning teachers to teach outside their specialization, had been reported years prior to the implementation of the new K-12 curriculum.

Citing the University of the Philippines National Institute for Science and Mathematics Education Development studies, Brawner (2011) reported that many practicing science teachers are non-science major graduates. These teachers were reported to have difficulty understanding concepts like electricity and chemical changes and reactions, and with less confidence to teach such content, they tended to concentrate only on topics they were conversant with. The "most alarming" part of the report was that students who gained the highest scores in the Trends International Science and Mathematics Study (TIMSS) 2003 performed better than their teachers when these teachers, for research analysis, took the same test. Hence, if viewed in terms of the teacher-participants' profiles from a region-wide perspective, the issue of teachers needing to have sound pedagogical and content knowledge (Shulman, 1996) on science subjects that they are teaching is completely valid.

Data (Figure 9) on the subject taught and the number of years clearly shows that regardless of the science subjects taught, most of the teachers were in their early years of teaching. The overwhelming majority of teachers were in their 1st to 3rd year of teaching experience followed by those in their 4th–6th year. These groups of teachers apparently need support similar to what the Ontario College of Teachers' (2003) study reported— namely, that even if new teachers are "incredibly passionate" about teaching, first and second year teachers in particular were given the most taxing teaching assignments with some asked to teach subjects they were not prepared for, and as a result had high levels of stress and were at risk of quitting their positions, and thus needed immediate help. New teachers need support because their teacher education programs cannot substantially prepare them for the emerging demands of the teaching profession (Heikkinen, Jokinen, & Tynjälä, 2008). They need support in professional competencies (Conway et al., 2009) and pedagogical mastery (Kane & Francis, 2013). Indeed, the supports they receive in their first years of teaching are highly essential for their career-long professionalism (Harju & Niemi, 2018).

Second, although the issue of insufficient and limited ICT and other instructional resources in public and rural schools is a prevailing concern in the country (Lapus, 2006; del Rosario, 2007; Bonifacio, 2013; Vergel de Dios, 2016; Pingol, 2016; Mateo, 2019), science teachers highlighted not “the [in]availability of ICT resources” but rather the “appropriateness of ICT resources” that can be maximized for students’ learning and teachers’ professional growth. Teachers have laptops, but only a very few have projectors in their classrooms. In fact, teacher-participants the likes of Ms. A use LED TV monitors purchased on their own initiative, while most of the teachers have to gather their students around their table at the center of the classroom to view presentations from their laptops. Other teachers have to exchange classrooms if they need to use the wide TV monitor as they have only one unit available for the seven of them in the department. They need to download online resources from their homes in advance, since they have weak or no Internet access at school. Most of the schools have computer laboratories, but these are only for computer classes and administrative purposes. Even if science teachers can manage to reserve the room for their class, Internet speed is still an issue.

DepEd is delivering more ICT packages in public schools as part of its on-going computerization programs, (DepEd, 2019); however, with the lack of Internet access, unstable power supply, limited ICT training programs for teachers, and demanding teaching loads, computers might not be maximized for learning. As a matter of fact, DepEd acknowledged that even if they have budget for Internet, it would be useless for schools in rural and remote areas where Internet providers are not present (Arayata, 2017). The World Bank report (2017) remarked that in order for ICT interventions to be effective, they should be implemented within the current school system’s available infrastructures and enhance the teaching and learning process.

Third, DepEd's on-going computerization programs delivering more ICT packages in public schools (DepEd, 2019) is welcomed by teacher-participants. However, teachers frequently mentioned in interviews and science video workshops the importance of investing in "appropriate ICT resources" for their professional development such as ICT competency and content and pedagogical knowledge. For them, one way of reducing the digital divide between students and teachers is to prioritize teachers more than students in ICT investments. Although they were not aware of any specific national standard on ICT competency for teachers like them, they need specific training for specific ICT skills that have immediate relevance to their science classes and students. Teacher-participants noticed that computers occupied spaces in their school faster than the delivery of professional training in ICT for them.

In 2017, Abanil, the current DepEd ICT director, confirmed that DepEd will boost ICT in public schools in 2018 and is at the same time in the process of compiling teachers' profiles to define their ICT competencies and match them with appropriate training (Arayata, 2017). This observation was similarly pointed out by Trucano (2016) in his report for the World Bank Education, Technology & Innovation paper series. He stressed that in terms of providing ICT-related training for teachers, support for teachers is "often deemphasized in the early stages of ICT rollouts" (p. 4). However, he further clarified that over time, implementing agencies "slowly invest in related technical and pedagogical professional development for teachers" (p. 4).

Fourth, teacher-participants were also in agreement that the use of FoK in their science classes raises students' awareness, understanding, and valuing of science concepts, community, and people. By using local data on past earthquakes, Ms. A extended discussion from conceptual earth science contents to mathematics and community preparedness during calamities, raising issues such as the structural integrity of houses. Ms. G's students debates on the use of organic and inorganic fertilizers expanded into discussions of issues that touched their family's livelihood and future sustenance as well as the environment and sustainability. Ms. H's activity on classifying volcanoes allowed students to literally watch a real volcano in their midst, constituting FoK as science literacy. Such critical engagements among students are crucial to "sustaining scientific discourse" and "construction of knowledge," as Erduran et al. (2007) collectively call argumentation in science education. In contrast, Ms. I's invocation of elders' beliefs about comets made her class excited to talk about their grandparents, but when science was included in the discussion of comets, students disengaged from the discussion. As teacher-participants observed, FoK may enhance their PCK and students' science literacy, but the use of FoK may also be a threat to developing students' scientific literacy and science argumentation skills. For Ms. I to reconnect and re-establish mutual respect and trust (Gonzalez et al., 2005) with her students, community, and science, she needs to understand how students and the community adhere to elders' position in the community (Ho, 1982; Limanonda, 1995; Ingersoll-Dayton & Saengtienchai, 1999).

7.2 Answer to Research Question 2

> In what ways are the encountered experiences related to (a) curriculum and pedagogy and (b) PD?

For curriculum and pedagogy, teacher-participants' requests for training to master other core science subjects' PCK are associated with the extent of engagement they shared during interviews, and further resurfaced during the science video workshop sessions and breaks in between. The whole process of video workshops (pre-production, production, and post-production) was a window for me to examine science teachers' TPACK and the extent of their FoK integration. Using Taber's (2005) metaphor of the "teacher-as-learning-doctor," teacher-participants' were able to identify key conceptions and misconceptions related to how they use scientific concepts and strategies in their videos. Their recognition of using terms like melts and dissolves, comet and asteroid, weight and mass, etc. interchangeably indicates that like their students, they have also some misconceptions. By identifying these misconceptions, they are able to "diagnose" learning impediments or learning "bugs" (Taber, 2005). The fact that the teachers were able to relate such learning impediments to wider conceptual and pedagogical contexts means they are able to develop the skill van Es and Sherin (2002) call "noticing." In van Es and Sherin's (2002) "Learning to Notice" framework, being able to notice and interpret an important event or experience in teaching and connect it to broader education principles are "important skills for teaching in the context of reform" (p. 572). Likewise, teachers' difficulty in developing a storyboard to retell the story of their video that would address students' realities does not represent an uncommon struggle for teachers. In fact, the process helps teachers themselves to question their own PCK and at the same time expands their knowledge about each of their students' needs. Koumi (2015) calls this process a means for teachers to enhance their cognitive engagement, constructive reflection, and collaborative learning skills.

As to the nature of professional development, teacher-participants' need for further professional training to improve their ICT competency as they teach other core science subjects outside their specialization was further validated during science video workshop sessions. My personal assessment of teacher-participants' level of ICT adoption (Figure 32) as related to the extent of their ICT usage and competency throughout the workshop sessions shows that teachers have higher awareness (emerging stage) of the potentials of ICT to enhance science instruction as matched in the thematic coding analysis of their positive beliefs and attitudes about ICT and its impact on pedagogy. However, as stages of ICT usage move higher, teachers' scores indicate that they have very minimal usage in applying, integrating, and transforming. This finding supports several studies that suggest the need for public school teachers to undergo further training related to ICT (Bonifacio, 2013; Vergel de Dios, 2017; Caluza, et al., 2017; Caluza, 2018).

Moreover, although video creation was a time-consuming process that involved a learning curve (with the added constraints of available facilities), teacher-participants were highly receptive to science video-creation workshop sessions as one form of professional development. It is seen as one purposeful platform for using appropriate technology for instruction (Milner-Bolotin, 2016). Examined further through the lens of TPACK (Koehler, Mishra, & Cain, 2013), teachers developed skills to communicate and reflect, and in the process acquired critical media literacy, communication, and presentation skills (Choe, 2017). I argue that these skills are what teachers should equip themselves with as they integrate FoK in their science classes to counteract the threat of worsening students' scientific literacy and argumentation skills (Erduran et al., 2007). Equally, with a pool of teachers possessing such skills, video-creation workshops can be initiated as one platform of professional development among teachers of science and other subject under DepEd's Learning Action Cell (LAC) (DepEd LAC). Video-creation workshops integrating FoK can also be added as a "mentoring the mentors" approach to support DepEd's Last Mile Schools program (Hernando-Malipot, 2019d). The Last Mile program is DepEd's initiative of reaching out to geographically isolated, disadvantaged, and conflict-affected areas to provide them with equal access to quality education.

In relation to the encountered experiences of science-teacher participants that overlap between curriculum and pedagogy and professional development, three highly crucial findings were advanced. First was the ability of teachers to (i) overcome "functional fixedness" of a technology and (ii) explore more creative ways such technology can function to improve science teaching and learning practices. This time, video technology vis-à-vis video-creation is not only used for students to learn science concepts but for teachers to create science stories, brainstorm how to diagnose learning impediments, perform voice recording, annotate visual aids, etc. With limited ICT resources in rural schools, the ability to overcome "functional fixedness" of a technology is highly welcomed. Second was the first documentation of a detached TPACK and expanded TPACK with the integration of FoK and ICT through science video creation by rural junior high school teachers. While the advent of newer educational technology influences the growth of teachers' TPACK, the use of FoK and technology to expand science teachers' TPACK stands as a significant contribution of this study to science education research. Third was when teachers started to become critical users of technology by identifying the affordances and constraints of technology as applied in science education.

7.3 Answer to Research Question 3

How are the experiences, especially the key challenges (a) transformed into enablers of dissemination of good practices and (b) informative of both institutional and government level policy frameworks?

Teacher-participants' struggles to integrate ICT in the new K-12 science curriculum despite limited resources allowed them to develop social resiliency and transformed them into new K-12 enablers in rural areas. Resilience is a physics term, from the Latin word *resilia* (to bounce back). Using the Charpy Test, a material's relative toughness is measured by determining how much impact energy it can absorb while breaking (Chellappa, 2017). Applied in psychology, resilience is the ability of an individual to adapt to stress and difficulties and to bounce back (Boquet, 2017). Social resilience as applied to teacher-participants means the ability of teachers as a department or as peers to cope with everyday difficulties in rural schools like having limited teaching resources or a weak Internet signal as they are trying to send important documents to DepEd office, etc. In a local context, the social resiliency of teachers is akin to a group of bamboo trees standing still against the strong winds, as in Flavier's description (1970) of rural reconstruction workers:

> Do you notice the graceful, stately bamboo? Its strength does not lie in its height but in its hollowness. It means it is ever hungry for knowledge, as there is much to learn. Then, it knows how to bend with the wind and does not break. (p. 84)

Select junior high school science teacher-participants may have not full mastery of all the core science subjects they were assigned to teach. However, they do not stop learning and teaching, and they always bend and bounce back despite challenges they face in schools every day. Their social resiliency has transformed them into resourceful innovators as well as enablers.
Enabling practices range from Ms. A.'s use of an LED TV monitor sourced from her former students, to holding a science or environmental pageant or camp and using the proceeds to buy teaching resources, to science teachers gathering together in a makeshift faculty room for ease of sharing content and pedagogical practices, to providing students with creative activities like

answering reflection questions during the transition period when teachers exchange classrooms to use a TV monitor, etc. During and after the science video workshops, teachers identified a number of potential uses of Camtasia and Snagit. To address the issue of limited textbooks in her science class, Ms. B. makes screenshots of textbook content, and then annotates and projects them on the LED TV monitor. Ms. C uses the software to record her voice to replace narration by British and English presenters. The lists and discussions of teachers' enabling practices were discussed in detail in pages under Theme 1: Enablers. These teachers' initiatives appear to reflect elements of teacher efficacy and altruistic motives (Campbell, 1990-1991), which in Smith and Strahan's (2001) research on identifying a prototype category of expert teachers indicate "teachers who have a sense of confidence in themselves and in their profession" (p. 364). There are several venues at school and division levels that can help spread teachers' enabling ideas and practices.

In a school level context, regular administrative faculty meetings, subject area meetings, and department head meetings could serve as platforms for sharing and conversation. In a school division level context, department heads and school principals could help scale up teachers' enabling practices to other schools through the presence of school division superintendents and subject area supervisors. Another prospective avenue to disseminate teachers' enabling ideas is DepEd's in-school professional development training called Learning Action Cell. Teachers who are becoming experts in science video creation could create video clubs where they mentor other teachers during cell sessions on how to create videos. Over time, teachers' video outputs can be synthesized into a pool or database of locally-based videos. The database can then be shared to schools and used during in-service trainings. As mentioned above, these videos can also be sent to remote and isolated rural schools under the DepEd's Last Miles Schools program.

On an institutional and policy level, the mitigation of the challenges faced by teacher-participants should start with a clarification of the definition for ICT. As early as 2008 (Flor, 2008), it has been recommended that DepEd should address an expanded definition of ICT at a policy level. Noting the mixed realities of public schools across the archipelago in urban, rural, and remote areas, an ICT definition should cover everything from high end (digital devices) to low end (analog devices) (Flor, 2008).

In 2019, the issue of an expanded definition of ICT is observable in the context of public and rural science teachers in this study. How DepEd and its teachers define ICT has considerable impacts on curriculum, pedagogy, and policy implementations. For example, when teacher-participants speak of "appropriate ICT resources" rather than "availability of resources," teachers know what they need. They know that they need a stable Internet connection, a wide projector, and quality science reference books. But when DepEd delivers ICT packages as part of its Computerization and Internet Connectivity Program, DepEd sends computer laboratory packages (desktop PC, wireless broadband router, uninterrupted power supply (UPS), inkjet printer, set of basic software and hardware), multimedia classroom packages (PC, LCD monitor, keyboard and mouse, interactive whiteboard, etc.), and tablet PC packages (DepEd, 2010; Santos, 2018). A quick review of several meanings of ICT shows a clear disparity between DepEd and Department of Information, Communication and Technology's definition of ICT and that of teacher-participants. According to Republic Act No. 10844 also known as DICT Act of 2015 (RA, 2016), ICT shall mean "the totality of electronic means to access, create, collect, store, process, receive, transmit, present, and disseminate information" (p. 1). According to other sources, ICT is an umbrella term for several media used in communicating information. In an educational context, according to this definition, ICT may cover computers, the Internet, television broadcasts, and even printed or handwritten notes (Oxford Dictionary, 2011; Butterfield & Ngondi, 2016). OECD (2018) categorized ICT as having three components: information technology equipment which includes computers and related hardware, communications equipment, and software. In addition, the definition of ICT is a "conceptual and methodological" problem as discussed by Livingstone (2012), which invites "confusion of diverse forms of educational technology under the umbrella term" (p. 13). Livingstone (2012) continues by saying that having different forms of ICT in different contexts of usage results in confusion and difficulty in "distinguish[ing] which aspects of technologically-mediated learning, if any, are effective in any particular situation" (p. 13).

7.4 Conclusions

This descriptive case study centered on the Philippines DepEd's new K-12 curriculum and ICT initiatives. Based on the findings from the combined quantitative and qualitative analyses, the following conclusions are advanced:

TPACK as a foundational professional development enabler. One of the most common challenges of select public and rural junior high school teacher-participants is the daunting task of mastering other core science subjects along with corresponding pedagogical techniques outside their subject expertise. The level of content and pedagogical mastery and preparation, even with their specialized core science subject, puts limits on how they can use ICT in teaching and learning. This is true despite the common understanding that their rural schools are facing a shortage of educational technology resources to use. Yet these key challenges have allowed them to develop social resiliency and sustained creativity. To recall some concrete proofs, Ms. A was able to outsource her LED TV from her former students, Ms. B and her co-teachers exchanged classrooms when they needed to use a single TV monitor fixed in one classroom, and Ms. B used Camtasia to create screenshots for visual aids while Ms. C recorded her voice as a narrator and interpreter in a video. Similar to other science video creation teacher-participants, Ms. B and Ms. C realized that a technology (e.g., video software) can have several functions beyond creating a science video. Indeed, these rural science teachers have shown that they have had several experiences of overcoming technology's functional fixedness. Experiences of overcoming fixation on what a particular technology's "perceived" function is (e.g., video) and starting to explore more creative ways such technology can function to improve teaching and learning practice are indications of professional growth.

The added value of overcoming functional fixedness of technology is that teachers are led to identify the affordances and constraints of a given educational technology in a rural school setting. Having a single LED TV in a school fixed in one classroom restricts science teachers from using a video or any media for their class. So, when Ms. B wanted to use a TV for her science class, she negotiated with teachers to exchange classrooms even in the middle of class. The perspective of overcoming technology's functional fixedness is, in fact, akin to some local practices among teachers in school or at home. They have a morning coffee packed in a sachet as a "2 in 1" or "3 in 1." The sachet holds not only the coffee but also the creamer and sugar. They also prepare their packed lunch for school by arranging the rice, fried egg, and hotdogs or fish all in one container. Like a coffee sachet, a container is seen to function not only by holding the rice, but also by accommodating portions of other foods for lunch without the need to use another container of a different size and shape.

Similarly, teachers like Ms. A carry with them a common philosophy in life that everything boils down to *diskarte*, a Filipino word for craftmanship or ingenuity. In a rural classroom context, overcoming technology's "perceived" function reduces rural school teachers' perennial problem of having limited educational resources. It drives the teachers to inquire into and explore different ways of using whatever technology they have in school to serve the different demands of the new K-12 curriculum and pedagogy. This is a distinct indicator of the growth of science teachers' TPACK.

FoK as a bridge to enhance teachers' TPACK. Integrating FoK in science class poses an extra challenge. Though it binds students to valuing science concepts, community, and people, its use also may represent a threat against the development of students' scientific literacy and science argumentation skills. To address the balance, teacher-participants should be mindful in acknowledging students' cultural beliefs (e.g., respect for elders) while introducing scientific concepts using ICT like locally based science videos.

Teacher-made science videos can enhance teachers' TPACK and FoK and in turn boost students' science literacy and argumentation skills. The pre-production through post-production of science video creation workshops allowed the science teachers to develop the skills to identify, examine, and relate teaching and learning impediments to wider curricular and pedagogical issues. These skills were also observed among science teachers who used Taber's (2005) metaphor of the "teacher-as-learning-doctor" and math teachers who framed their video observations using van Es and Sherin's (2002) "Learning to Notice" frameworks. Moreover, for the first time, this study has shown that science teachers' TPACK can be detached, expanded, and reconnected while integrating FoK in their science classes. A detached TPACK is a disservice to quality science teaching, while an expanded TPACK potentially support teachers' PD in teaching and learning, particularly when ICT and FoK are used simultaneously in science video creation. This study showed that the expansion of TPACK due to an outside component (use of FoK) disrupts a well-established precept of TPACK that tell us that TPACK components are in "a state of dynamic equilibrium" and a change in any of the factors or components has to be "compensated by" changes in the other two (Mishra & Koehler, 2006, p. 1029). Teacher-made science videos as a practiced-based PD program have the capacity to foster measurable learning for teachers. If science video creation works for science teachers, then teachers in other STEM fields can most likely benefit from it as well. Apparent growth of science teachers' TPACK through science video creation from this study was also seen in several research studies showing that use of technology like video in a deliberate manner enhance teachers' peer collaboration, cognitive engagement, and constructive reflection (Koumi, 2015; Choe, 2017; Mliner-Bolotin, 2016, 2019; Tembrevilla & Milner-Bolotin, 2019). Over time, looking at the new K-12 curriculum in the Philippines, the science video creation workshops could lead to an expanded "video clubs" as a form of PD program under the DepEd's Learning Action Cell.

The successful implementations of ICT-centered science curriculum and pedagogy as policy and governance dependent. Rural junior high school science teachers were receptive to the use of ICT in their classes. They had positive beliefs and attitudes toward the potential of ICT to improve learning outcomes. However, teachers highlighted not "the limited availability of ICT resources" but rather the "appropriateness of ICT resources" that they can maximize for their professional growth and their students' learning. Another issue was the scope of definition of ICT. Does ICT cover older and low tech forms like books, or does it cover only high tech and purely digital forms? How does such definition and scope of ICT address the actual needs of rural school teachers, which are distinctly different from teachers in urban schools? At an institutional and policy level, the mitigation of the challenges faced by teacher-participants should start with a clarification of the definition for ICT. How DepEd leaders and its teachers define ICT has considerable impacts on curriculum, pedagogy, and policy implementations. Different definitions imply different interpretations. The differences in interpretation in turn result in a different focus in policy implementation, investments, and recommendations. All of these challenges lie with institutional policy on ICT initiatives' terms and implementations, and the solutions to successful implementation are policy and governance dependent.

7.5 Research Implications

Theory

With the diverse scope of ICTs as used in teaching and learning, a definitive description of what and how specific ICT improves instruction or not should be properly delineated. Teachers' comments on needing "appropriate ICT resources" in schools are partly related to a mismatch of what DepEd delivers in its ICT initiative known as the Computerization and Internet Connectivity Program. Flor (2008) observed that there are ICTs that are more appropriate in rural schools than in urban schools. As pointed out by Livingstone (2012), there are "diverse forms of educational technology under the umbrella term ICT," and if research claims that ICT enhances learning, "it is difficult to distinguish which aspects of technologically-mediated learning, if any, are effective in any particular situation" (p. 13). The Philippine Department of

Information and Communication Technology's definition of ICT is seemingly applied by DepEd though not completely applicable to the context.

In the context of education, ICT does not only mean the "totality of electronic means to access, create… [and] disseminate information" (RA, 2016, p. 1), but may include even "printed and handwritten notes" (Oxford Dictionary, 2011; Butterfield & Ngondi, 2016). This definition of ICT fits, for example, science teacher-participants' requests for quality science reference books as part of what they meant by "appropriate ICT resources." The importance of defining ICT based on agreed upon principles and perspectives should not be underestimated. Different definitions of ICT will lead to different policy investments, implementations, and recommendations (Glewwe et al., 1988; Flor, 2008).

Curriculum and Pedagogy

ICT is a welcome tool in schools, but for teachers in rural schools, content and pedagogy should come first, followed by technology. The first initial letter in TPACK stands for "Technology" and is meant for easy recall only; for any ICT policies in education to be impactful, content and pedagogy—the PCK in TPACK—should be in line first, with technology following. However, as researchers have noted (Flor, 2008; Lubin, 2018), most bilateral ICT initiatives among developed and developing countries funded by international donors and organizations are not primarily curricular and pedagogy-driven; that is, they are not based on teachers' priority needs but rather on donors' and technology-providers' agendas. If there is a paucity of empirical and research-based evidence on teaching, teachers, and individual schools' current systems and infrastructures, then any ICT policies implemented in the context of education will have reduced impacts on teaching and learning in schools (Trucano, 2016).

One lesson learned from the experiences of teacher-participants is that, first and foremost, ICT policies and initiatives in education should invest more in teaching and teachers (Behar & Mishra, 2018). Although Trucano (2016) noticed that across government, state, and implementing agencies, teachers are sidelined in initial ICT initiative implementations, the World Bank (2017) argues that any technological interventions can strengthen learning only if they boost the teaching and learning process. Some findings from this study, for example, (1) having LED TV monitor in the classroom was a valuable device in teaching and learning in rural schools; (2) the science video-creation as a practiced-based PD was an effective form of PD in rural schools; and (3) rural school teachers could expand their TPACK with the use of students' FoK along with ICT, independently complement the World Bank's (2017) argument that in order to boost curricular and pedagogical innovation in rural schools, ICT investments should match the current system and infrastructure of schools and preparation of teachers.

Looking at the current educational systems around the world impacted by the Covid-19 pandemic, the urgency to overcome technological, pedagogical, and curricular infrastructure barriers to fill in teaching and learning gaps with school closures is overwhelmingly felt. The current crisis has exposed an older problem that many teachers, either in urban or rural, have "rarely had a chance to acquire the required twenty-first century skills" (Ben-David Kolikant, Martinovic, & Milner-Bolotin, 2020, p. 3). From teacher education programs to actual teaching practices, research has shown that there is a need to understand, particularly for teachers, how to support them to acquire twenty-first century skills like collaborative and critical thinking skills with ICT to participate in "mutually supportive, online, and physically situated learning spaces" (Gomez & Lee, 2015, p. 649). Teaching and teachers in this time of uncertainty need a holistic approach of combining deliberate use of ICT, teachers' PD, and administrative support. However, such approach is also matched with resistance in the form of limited ICT resources, teachers' beliefs and attitudes toward the use of technology in class, and inconsistent administrative support and leadership.

Future Research

As early as the 1950s, the Philippine Sociological Society observed that rural high school education was the most critical area of education (Coller, 1954). It served as an "agency for the reduction of rural-urban differences" (Coller, 1954, p. 2) by standing mid-way between the barrio elementary school (traditionally familistic) and the college or university (generally urbanistic and individualistic). Though the use of FoK and ICT in science video-creation in this study had shown that rural junior high school teachers were capable to develop students' science argumentation and literacy, there is a need to consider the quality and sustainability of such PD. In fact, recent study warned that since there were limited understandings on science literacy across racial and ethnic groups (NAS, 2016), "educational interventions need to measure, and target, not just the quantity of instruction and formal qualifications…but also quality" (Alum, Besley, Gomez, & Brunton-Smith, 2018, p. 862).

Rural public high schools are generally viewed as passive, marginal, ignorant, and pathological (Woodrum, 2011). For Theobald and Wood (2010), "rural equals backward is an old cultural message, but its age hasn't diminished its utility" (p. 31). Yet in this study, the rural schools where teacher-participants work and live are resourceful and resilient. The limited teaching resources in schools transformed teachers into innovative enablers. In their research on poverty and school achievement in rural communities, Howley and Howley (2010) found that people living in rural communities are "astoundingly productive" and "self-provisioning" (p. 35). The old stereotype pointed out by Theobald and Wood (2010) is legitimizing "policy measures that are demonstrably unfair to rural locales" (p. 31).

Despite the fact that rural communities are sidelined by policies, the rural school teachers in this study are mostly receptive to new ideas. They have rich ideas, and that makes them valuable. They widely accepted the science video creation workshops. These workshops can generate professional groups like video clubs in their schools. With proper training and consistent support from schools, these video clubs will be the training grounds for public and rural school teachers to further integrate FoK. Likewise, creating videos with colleagues will potentially enhance their TPACK competency through peer collaborations (Milner-Bolotin, 2019). Over time, a pool of expert teachers in video creation would grow and could serve as mentors for PD among colleagues in school and division level Learning Action Cells. These teachers can also be tapped to reach out to remote and isolated rural schools as a support to DepEd's Last Mile Schools program.

For sustainability and continuity, the pool of expert teachers across subject areas and school divisions could create sets of locally based videos that can be organized and managed as a database of teaching and professional development training resources. Science video creation as a professional development tool for teachers in public and rural schools might add to the limited literature valuing rural schools as places of innovation for collaboration and alternatives of pedagogical effectiveness (Schafft & Jackson, 2010; Stelmach, 2011; Tieken, 2014). Further enabling rural school teachers, may it be in developing countries like the Philippines or in developed countries like Canada, to transform rural education through informed policy in the implementation of ICT-based PD, enhanced curriculum and pedagogy, and strong administrative support can (1) help address calls for equity, diversity, and inclusion in education brought about by rapid economic, political, and cultural globalization and (2) reshape 21st century digital society, extremely relevant to the current times with the Covid-19 pandemic.

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Appendices

Appendix A : Full Survey Questionnaire

Appendix A: Full Survey Questionnaire

Faculty of Education Department of Curriculum and Pedagogy
Neville Scarfe Building 2125 Main Mall, Vancouver, BC, Canada, V6T 1Z4

Challenges of Public High School Science Teachers in the Philippines in Integrating Technology in Science Education

I. Who is conducting the study?
Principal Investigator: Marina Milner-Bolotin; marina.milner-bolotin@ubc.ca; 604–822–4234 Primary Contact: Gerald Tembrevilla; gtembs@mail.ubc.ca; (+1)-778-939-3315

II. Who is funding the study?
This study is partly supported by the UBC Department of Curriculum and Pedagogy and Public Scholars Initiative (PSI).

III. Why are we doing this study?
This study will look into the challenges of select public high school science teachers face when they integrate technology in their science teaching within public high schools in the Philippines.

IV. How is this study done? Outcomes from this work will only be made available to the PhD committee of Gerald Tembrevilla after data has been anonymized. The study involves anonymous analysis of data of science teacher participants like this UBC Qualtrics Survey.

V. Study results
Study results will be reported in an anonymized and aggregate fashion. The study's findings might be published in academic journal articles, and discussed within the broader UBC community.

VI. Is there any way being in this study could be bad for you? There is no way participating in this study could be harmful to science teachers.

VII. What are the benefits of participating? By joining in the study, science teachers responses might inform how current curriculum and policy will harness the potentials of ICT not only in science but also in other STEM (science, technology, engineering, and mathematics) subjects in Philippine public education settings.

VIII. How will your privacy be maintained? Data will be securely stored on encrypted computers and/or personal laptops and shared with each other using a FIPPA and PIPEDA compliant (federal government mandated) solution. Teacher participants' identifying numbers will be stripped and replaced with digit codes to track entries; your confidentiality will be respected and information that discloses your identity will not be released unless required by law.

IX. Who can you contact if you have questions about the study?

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598. Taking part in this study is entirely up to you. You have the right to refuse to participate in this study.

Contact for information about the study:

If you have any questions or desire further information with respect to this study, you may contact Gerald Tembrevilla (gtembs@mail.ubc.ca) or call (+1)-778-939-3315.

Consent

#	Answer	%	Count
1	I DO consent to having my responses included in the study. I understand that my participation in this study is entirely voluntary and may refuse to participate or withdraw from the study at any time without jeopardy of my status as a science teacher.		
	Total		
	I DO NOT consent to having my responses included in the study. I understand that my participation in this study is entirely voluntary and may refuse to participate or withdraw from the study at any time without jeopardy of my status as a science teacher.		
	Total		

Demographic (D) Profiles

D1. I belong to the Schools Division of _____.

D2. I am teaching _____ (subject/s) (tick all that apply) for (please write the number of years in the box) _____.

General Science Earth Science Biology Chemistry Physics

D3. My bachelor's degree is in _____.

Education Others _____.

D4. My master's degree is in _____.

Education Others _____.

D5. I have not graduated yet but have earned units leading to master's degree in _____.

D6. Someone defined technology as "crossing the river without getting my feet wet". Others described technology by citing the efficiency of MS Excel in computing for students' grades. As a science teacher, how do you define technology?

D7. Do you have Internet connection provided by the school for science class use?
Yes
No. I am using my personal data subscription.
Others/comments.

D8. Do you use a laptop in your science class?
Yes No

D9. In what ways do you use your laptop in your science class? Which one did you do most frequently for the last four weeks?
To show a video about a science concept, through online link or power point
To show diagram, pictures, or illustration of science concept
To send emails, announcement to students
For online quiz, games, puzzles
For assignments, short quiz
Others

D10. In what ways do you use your laptop in your science class? Which one did you do least frequently for the last four weeks?
To show a video about a science concept, through online link or power point
To show diagram, pictures, or illustration of science concept
To send emails, announcement to students
For online quiz, games, puzzles
For assignments, short quiz
Others

D11. What specific trainings on the use of technology that you think are more appropriate in your science class now? Multiple answers allowed.
Bridging teaching strategies using online resources and students' local context
Connecting multimedia – TV monitor, projector, computer, printer
Creating multimedia presentations – power point, video
Choosing the best science teaching resources online
Developing multimedia presentation skills
Others

D12. What difficulties have you faced when you use any technology in your science class for the last four weeks? Multiple answers allowed.
Not confident enough if I have used, demonstrated, and explained such technology correctly
No available staff, colleague to assist in cases such technology malfunctions
Not convinced if such technology were appropriate for a given science topic
Not completely functional or working, defective, old
Limited availability, not enough for the class

Limited knowledge to troubleshoot
No or slow Internet connection

D13. What were the ideas, concepts, beliefs, and practices related to the community, students, students' families, students' history and culture, etc. that you have used in your science class inside and outside the classroom to help students understand or appreciate science concepts and theories for the last two grading periods? Multiple answers allowed.
Parents', grandparents' and elder people's experience and wisdom
Religious symbols, beliefs and practices – fiesta, festivities, etc.
Professions, jobs, hobbies within the barangay/community
Lands, rivers, seas, mountains, hills, landscapes, etc.
Local and indigenous music, news, sports, arts
Local agriculture, fishing, business practices
Gender, marriage, religion, laws

D14. What difficulties have you faced when you use any of the ideas, concepts, beliefs, and practices related to the community, students, students' families, students' history and culture, etc. in your science class for the last two grading periods? Multiple answers allowed.
Not confident enough if I have used, demonstrated, explained such ideas and concepts correctly

Not convinced if such ideas and concepts made students learn or understand science
Not confident enough if such ideas and concepts were relevant and proper to use
Not motivated to use such ideas and concepts
Not enough time for one period and class

Challenges
Q1. I am convinced that integrating technology in science teaching improves teacher-student interaction.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q2. I am convinced that integrating technology in science teaching improves students' understanding of science.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q3. I am convinced that integrating technology in science teaching improves teacher confidence in the use of technology.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q4. I am convinced that integrating technology in science teaching reduces digital divide between teacher and student.
Strongly Agree Agree Neutral Disagree Strongly disagree

Questions #5-#7 apply to ICT initiatives implemented in any levels from two years ago or much later

Q5. Were there useful/relevant ICT (information and communications technology) projects or initiatives from your Division level implemented in science in your school?
Strongly Agree Agree Neutral Disagree Strongly disagree

Q6. Were there useful/relevant ICT (information and communications technology) projects or initiatives from your Region implemented in science in your school?
Strongly Agree Agree Neutral Disagree Strongly disagree

Q7. Were there useful/relevant ICT (information and communications technology) projects or initiatives from the National level implemented in science in your school?
Strongly Agree Agree Neutral Disagree Strongly disagree

Q8. My school's division provided relevant technology for science teaching four weeks ago.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q9. My school's division provided relevant technology for science teaching last year.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q10. My school's division provided relevant technology for science teaching two years ago.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q11. My school's division provided relevant technology training for science teachers two weeks ago.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q12. My school's division provided relevant technology training for science teachers last year.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q13. My school's division provided relevant technology training for science teachers two years ago.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q14. I am convinced that students learn and understand more about science when ideas, concepts related to the community are integrated with technology.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q15. I am convinced that students learn and understand more about science when beliefs, and practices related to the community are integrated with technology.
Strongly Agree Agree Neutral Disagree Strongly disagree

Q16. I am confident that I have the needed knowledge of my science contents in order for me to choose appropriate technology to use in my science class four weeks ago.
Strongly Agree Agree Neutral Disagree Strongly disagree

Appendix B : Interview and Focus Group Questions

University of British Columbia (UBC)
Faculty of Education
Department of Curriculum and Pedagogy
Neville Scarfe Building
2125 Main Mall, Vancouver, BC, Canada, V6T 1Z4

Interview & Focus Group Questions

One-on-one Interview Questions

7. Why did you answer that these (from UBC Qualtrics Survey) are the common problems you encountered every time you use tools/gadgets in your science class?
8. What were the trainings/workshops did your principal/department head asked you to participate for the last 3 years?
9. Have you attended all of them? Why and why not?
10. What were the things you learned that helped you improve your teaching?
11. What were the things you wished you learned in those trainings/workshops? And why?
12. How important is it for students in science to integrate **ideas/concepts/beliefs/practices** related to the **community, students, students' families, students' history/culture**?
13. In what ways can your school administration and the division in general help/assist you to level up your knowledge and confidence to use technology in your science class?
14. 2-3 years from now, what do you foresee for the following?
    a) What programs or training/workshop will the school/division offer on ICT?
    b) Your level of confidence and knowledge in using ICT in your science class
    c) Any support that your school administration will provide

Focus Group Questions

5. Why is it that most of you mentioned that these (from UBC Qualtrics Survey) are the common problems you encountered every time you use tools/gadgets in your science class?
6. How can you keep up yourself as a teacher with your students in terms of being confident and knowledgeable in using these tools/gadgets/computers/APP/etc.?
7. In what way can your school administration and the division in general help/assist you to level up your knowledge and confidence to use technology in your science class?
8. How do project on 2-3 years from now?
    d) What programs or training/workshop will the school/division offer on ICT?
    e) Your level of confidence and knowledge in using ICT
    f) Any support that your school administration will provide

Appendix C : Science Video-Creation Workshop

Science Video Creation Workshop(Adapted from Media Production Workshop for UBC Learning Technology Rovers & Scientific communication: Creating explainer videos on STEM topics '18)
https://www.lrng.org/university-of-british-columbia-faculty-of-education/playlist/scientific-communication-creating-explainer-videos-on-stem-topics-18
Steps in STEM video creation:
PRE-PRODUCTION

Conceptualization: Where do these ideas for the demo come from? An interesting idea springs from ordinary events or situations yet, by keeping connected to your previous experiences and interests, these events can be transformed into new concepts and ideas to create a video. We call this idea "I wish" or "Aha moments".

Planning: **Who is your target audience?**
First and foremost, consider who is your target audience. Knowing your audience will allow you to deliver the right message and impact. It will inform you of the choice of vocabularies to be introduced, the appropriate gestures and expressions needed, the complexities of the equipment to be shown, etc.

> **What material do you need? What's the best location to film the demonstration? or** a demo video, the suitability of material to the intended audience, safety, and depth of the concept/s and discussion to be introduced is paramount.
> **What does your storyboard look like?** Storyboard is your story organizer and script. It allows you to illustrate and sequence your ideas for a video. It prompts you on the Major components of your presentation.

Practice: Before you pick up the camera, practice your delivery with some audiences. Act out your storyboard. No need to memorize it. Just notice and note the peculiarities for example:

PRODUCTION
Record
This step strongly suggests that you should start recording the raw footage (and be ready to do multiple takes) of the actual demonstration.
Edit In this stage, the best recorded raw video will be used. You are now transferring the raw video into an editing software. There are several video editing software available. Proper citation and attribution of external resources should be followed as provided by this guide (from "What is it" to "How to get started" portions).

POST PRODUCTION
Review, Presentation & Evaluation:
In this last stage, before uploading your finished demo video to any platform, i.e. YouTube, etc. solicit feedback among friends and community online, teachers, and experts.
Be open to new ideas and criticisms. Integrate and re-edit your video. Presentation and critiquing.

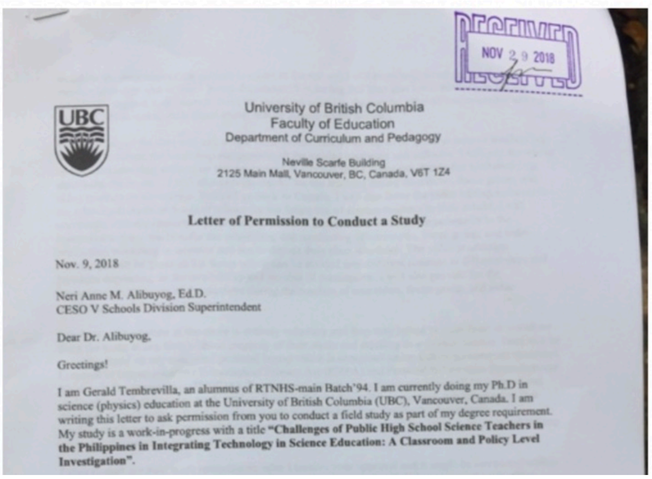
Appendix D : UBC Behavioural Ethics Approval

The University of British Columbia
Office of Research Services
Behavioural Research Ethics Board
Suite 102, 6190 Agronomy Road, Vancouver, B.C. V6T 1Z3

CERTIFICATE OF APPROVAL - MINIMAL RISK AMENDMENT

PRINCIPAL INVESTIGATOR:	DEPARTMENT:	UBC BREB NUMBER:
Marina Milner-Bolotin	UBC/Education/Curriculum and Pedagogy	H18-02992

Appendix E : External Approvals: Division and Region VI



RECEIVED NOV 29 2018

University of British Columbia
Faculty of Education
Department of Curriculum and Pedagogy

Neville Scarfe Building
2125 Main Mall, Vancouver, BC, Canada, V6T 1Z4

Letter of Permission to Conduct a Study

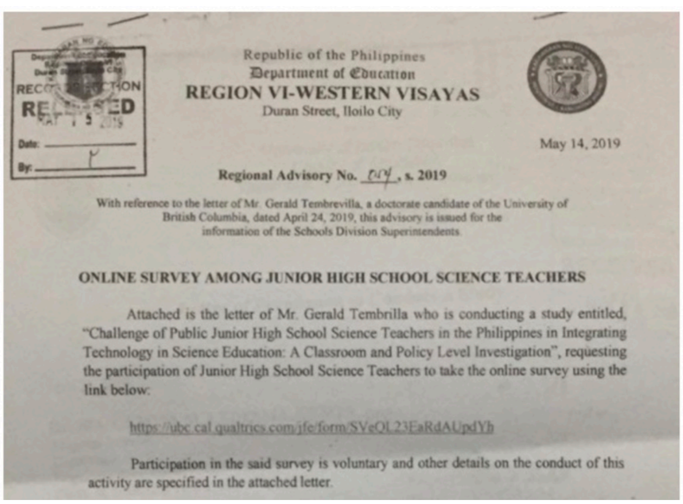
Nov. 9, 2018

Neri Anne M. Alibuyog, Ed.D.
CESO V Schools Division Superintendent

Dear Dr. Alibuyog,

Greetings!

I am Gerald Tembrevilla, an alumnus of RTNHS-main Batch'94. I am currently doing my Ph.D in science (physics) education at the University of British Columbia (UBC), Vancouver, Canada. I am writing this letter to ask permission from you to conduct a field study as part of my degree requirement. My study is a work-in-progress with a title **"Challenges of Public High School Science Teachers in the Philippines in Integrating Technology in Science Education: A Classroom and Policy Level Investigation"**.



RECEIVED

Date:
By:

Republic of the Philippines
Department of Education
REGION VI-WESTERN VISAYAS
Duran Street, Iloilo City

May 14, 2019

Regional Advisory No. 014, s. 2019

With reference to the letter of Mr. Gerald Tembrevilla, a doctorate candidate of the University of British Columbia, dated April 24, 2019, this advisory is issued for the information of the Schools Division Superintendents.

ONLINE SURVEY AMONG JUNIOR HIGH SCHOOL SCIENCE TEACHERS

Attached is the letter of Mr. Gerald Tembrilla who is conducting a study entitled, "Challenge of Public Junior High School Science Teachers in the Philippines in Integrating Technology in Science Education: A Classroom and Policy Level Investigation", requesting the participation of Junior High School Science Teachers to take the online survey using the link below:

https://ubc.ca1.qualtrics.com/jfe/form/SVeOL23EaRdAUpdYh

Participation in the said survey is voluntary and other details on the conduct of this activity are specified in the attached letter.

Appendix F : Invitation Letter

University of British Columbia (UBC)
Faculty of Education
Department of Curriculum and Pedagogy
Neville Scarfe Building
2125 Main Mall, Vancouver, BC, Canada, V6T 1Z4

Research Study Invitation Letter

Challenges of Public High School Science Teachers in the Philippines in Integrating Technology in Science Education: A Classroom and Policy Level Investigation

Dear Science Teacher,

You are being invited to take part in this research study because you are a teacher who belongs to the Schools Division of Bago City, Negros Occidental, Philippines. This study was approved by your schools superintendent and the copy was furnished to your school principal and department head.

This study will look into the challenges of select public high school science teachers face when they integrate technology in their science teaching within public high schools in the Philippines.

Your participation will involve giving us permission to use your data from UBC Qualtrics Survey, one-on-one interview, focus group discussion, and science video production training workshop.

Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time without jeopardy of your status and standing as a science teacher.

To opt-in or opt-out of the research component of this study, kindly follow this LINK. If you opt-in, you will be asked to provide your email address and initials. Gerald Tembrevilla, the researcher, will send you the Survey link using your email. All teachers who will opt-in and opt-out will be included in the lottery and 30 teachers will receive a $13 (Canadian) honorarium.

This survey should take approximately 15-20 minutes to complete, depending on your Internet speed. Thank you in advance for your participation!

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598.

You may also contact Gerald Tembrevilla, PhD Candidate, UBC Faculty of Education, Curriculum and Pedagogy gtembs@mail.ubc.ca (+1)-778-939-3315

Kind regards,
Your Principal

Appendix G : Consent Letter

University of British Columbia
Faculty of Education
Department of Curriculum and Pedagogy
Neville Scarfe Building
2125 Main Mall, Vancouver, BC, Canada, V6T 1Z4

Consent Form

Challenges of Public High School Science Teachers in the Philippines in Integrating Technology in Science Education: A Classroom and Policy Level Investigation

I. Who is conducting the study?
Principal Investigator: Marina Milner-Bolotin; marina.milner-bolotin@ubc.ca; (+1) 604–822–4234
Primary Contact: Gerald Tembrevilla; gtembs@mail.ubc.ca; (+1) 778-939-3315
II. Who is funding the study?
This study is partly supported by the UBC Department of Curriculum and Pedagogy and Public Scholars Initiative (PSI).
III. Why are we doing this study?
This study will look into the challenges of select public high school science teachers face when they integrate technology in their science teaching within public high schools in the Philippines.
IV. How is this study done?
The study involves anonymous analysis of data of science teacher participants like UBC Qualtrics Survey, one-on-one interview, focus group discussion, and science video production training workshop. Teacher-participants will receive the Consent Form through email from their respective principal. The form will provide the links for them to either opt-in or opt-out in the study. The primary contact, Gerald Tembrevilla, an alumnus of RTNHS-main Batch"94, manages these links. Regardless if teachers opt-in or opt-out, all will be included in a lottery where 20 teachers will receive $13 honorarium. Those who will opt-in will provide their email address. This is the email address that will be used by Gerald to send them the survey and arrange the interview, focus group, and video production training.
In cases where one-on-one interviews, focus group, and science video production fall during teachers' classes, they will be encouraged to prepare activities for their students and arrange a substitute teacher to watch and supervise the class in advance. Below is the short summary of each activity:
Qualtrics Survey –teachers will be asked on what kind of information and communications technology (ICT) they have used and been using in their science classes. It will also ask about their opinion on the value of funds of knowledge (FoK) being integrated in science teaching and learning. It can be completed approximately in 15-20 minutes.

One-on-one Interview – teachers will be asked more specific questions on how they integrate ICT and FoK in their science classes in 30-45 minutes.

Focus Group – 2-5 teachers in a group will be asked more specific questions on how they integrate ICT and FoK in their science classes in 45-60 minutes.
Science Video Production – teachers will be trained on how to create short 3-5 minute science videos integrating FoK in science and at the same develop their ICT skills in 1-3 sessions. One session is between 1-2 hours.

Science teachers' participation in interview, focus group, and science video production will likely be known by their principals and other teachers. However, the data that will be generated through their involvement and participation will be protected by anonymizing them and properly kept in password protected and encrypted computer.

V. Study results

Study results will be reported in an anonymized and aggregate fashion. The study's findings might be published in academic journal articles, and discussed within the broader UBC community.

VI. Is there any way being in this study could be bad for you?

There are no foreseen risks to participating in this study.

VII. What are the benefits of participating?

By joining in the study, science teachers responses might inform how current curriculum and policy will harness the potentials of ICT not only in science but also in other STEM (science, technology, engineering, and mathematics) subjects in Philippine public education settings.

VIII. How will your privacy be maintained?

Data will be securely stored on encrypted computers and/or personal laptops and shared with each other using a FIPPA and PIPEDA compliant (federal government mandated) solution. Teacher participants' identifying numbers will be stripped and replaced with digit codes to track entries; your confidentiality will be respected and information that discloses your identity will not be released unless required by law. During the focus group, confidentiality cannot be completely guaranteed but teacher-participants are strongly encouraged to keep what was discussed in group private.

IX. Who can you contact if you have questions about the study?

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Ethics at 604-822-8598 or if long distance e-mail RSIL@ors.ubc.ca or call toll free 1-877-822-8598. Taking part in this study is entirely up to you. You have the right to refuse to participate in this study.

X. To opt-in of the research component of this study, kindly follow this LINK. In the link, kindly check the opt-in box and affix your initials (Name and Surname) below it as your signature.

Contact for information about the study:

If you have any questions or desire further information with respect to this study, you may contact Gerald Tembrevilla (gtembs@mail.ubc.ca) or call (+1)-778-939-3315.

Appendix H : Observation Protocol Matrix

Level of Adoption &Indicator / Teacher	A	B	C	D	E	F	G	H	I	J
Emerging: Becoming aware of the potentials of ICT in education	**40-45**	**40-45**	**46-50**	**46-50**	**40-45**	**40-45**	**40-45**	**40-45**	**46-50**	**46-50**
* realize which science content ICT can be of used	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
* identify specific ICT tool can be used	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
*believed/convinced that ICT can support student learning	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Applying: Beginning to learn how to use ICT for teaching and learning	**20-24**	**26-30**	**26-30**	**26-30**	**26-30**	**20-25**	**20-25**	**20-25**	**36-40**	**30-35**
* use laptop for power point presentation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
* use laptop for PowerPoint presentation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
* use software programs (e.g., Word) for science	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Integrating: ICT is used and matched into the curriculum	**6-10**	**6-10**	**1-5**	**1-5**	**1-5**	**1-5**	**1-5**	**1-5**	**16-20**	**16-20**
* specify ICT tool for specific lesson coverage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
* outline specific science contents and strategy for ICT to be used	No	No	No	No	No	No	No	No	Yes	Yes
* outline specific science contents and strategy for ICT to be used	No	No	No	No	No	No	No	No	No	No
Transforming: Innovation and development of new ways of teaching and learning using ICT	**1-5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1-5**	**1-5**
* create inquiry-based activity where use of ICT is crucial	Yes	No	No	No	No	No	No	No	Yes	yes
* encourage students to create applications and solutions with the use of ICT	No	No	No	No	No	No	No	No	No	No
* challenge students to explain and communicate science concepts\ with ICT	No	No	No	No	No	No	No	No	No	No